




BASICS OF ENVIRONMENTAL SCIENCES

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Title: Basics of Environmental Sciences

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ISBN:978-81-930460-5-0
Year: 2018
Edition: 1st
Publisher:/Distributer: Iqra Publishers, Jammu, J&K/New Delhi, India

IQRA PUBLISHERS Dehrot, Rajouri, J&K

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Preface

Declining natural resources, vanishing biodiversity, receding glaciers, rising sea levels, degrading soils, warming earth, depleting ozone layer, extreme weathers and unprecedendented climatic changes are the indicators as well as the consequences of a chaotic situation on the earth. Man's excessive encroachment on the natural environmental domains is mainly responsible for this messy ecological state of affairs in his surroundings. Need has strongly been felt worldwide to do something in order to stop or lessen, if not reverse, these unfavorable changes in the environmental components of the planet. United Nation's first ever conference on world's environmental problems held at Stockholm in 1972 followed by a large number of such events thereafter is a reflection of this realization. India is an important signatory to most of the international conventions and agreements which aims at environmental protection and has framed policies and laws to pave the way for implementation of the decisions taken at international fora. There are many a laws, acts and rules aiming to control environmental pollution, save forests and protect biodiversity. Public awareness, however, is equally important in dealing with environmental issues. Acknowledging its importance, the UGC has made teaching of Environmental Studies mandatory at undergraduate level.

This book, more or less in accordance with the course designed by the UGC, is an attempt to present basic and indispensable information on environment and environmental crises in a simple capsulated form to be equally useful for students, environmental activists and commoners.

Book is structured in a format consisting of various sections viz. **Abstract**, **Introduction**, **Details and Discussions** and **Recaps and Practices**. Care has been taken to present every bit of relevant information about the topics under discussion in a simpler manner. Repetition has been avoided as far as possible. Every attempt has been made to make the book interesting and attractive not only for the college students but also for a common reader.

Originality in academic writings is often an elusive and dubious claim particularly when it's about the writings/books meant for students of a particular subject. Authorship, here, largely entails editing and compiling. Various works on the subject have been consulted for the preparation of this book and I, humbly and respectfully, acknowledge the help and facilitation I have received from them all irrespective of whether they are listed or not in the text/bibliography.

Your positive criticism and suggestions are warmly welcomed.

Junaid Jazib

Acknowledgement

Besides being grateful to the Almighty Allah, the creator and the sustainer, I am always indebted to my loving parents who inculcated in me the respect for humanity and love for nature. I do acknowledge the guidance and support of my uncle, Jb Gh Qasim who has always been a source of inspiration for me.

I can't overlook the support and cooperation extended by my younger brother, Er. Qayoom, and sisters-Qulzam, Rehana, Zetoon and Zahida-during the preparation of this book.

Very special thanks are due to my teachers including Prof R. K. Rampal, Prof A. K. Raina, Dr. Sanjay Sharma, Dr. Piyush Malviya, Dr Deepika Slathia and Dr. Neeraj Sharma and my friends-Shamim (J&K Education), Rohit (WWF-India), Rakesh (Deptt of Env Sc, JU), and Nisar (Education Deptt, Ladakh) for their valuable and perfecting suggestions.

I express my earnest thankfulness to Mr Shabir A Rather, Founder Iqra Foundation (J&K) for his moral support and guidance during our environmental activism since last many years.

Lastly I have to express my gratitude to Erum, my better half, for her pivotal role in all my endevours.

Junaid Jazib

ENVIRONMENTAL CALENDAR

In order to make global community aware about various environmental issues and to work for environmental protection different events are organized at local, national and international levels. Some of the important days are:

World Wetland day	**2nd Feb**
International Polar bear day	**27th Feb**
World wildlife day	**3rd March**
International day for actions for rivers	**14th March**
World Forestry Day	**21st March**
Water day	**22nd March**
Earth Day	**22 April**
Green day	**4th May**
World Biodiversity day	**22nd of May**
World Environment Day	**5th June**
World Population day	**11th July**
Tiger Day	**29th July**
Ozone Day	**16th September**
Zero emissions Day	**21st September**
World Soil Day	**5th December**

About the Author

Junaid Jazib is an academician, a committed environmentalist, a social activist and a prolific writer on environmental issues. With more than ten years of experience in teaching and research, he is currently HoD, Environmental Studies at Govt Degree College Thannamandi, (J&K). He is also associated with several national and international organizations working for environmental protection and sustainable development. He's got UGC's prestigious Teacher Fellowship (under FDP) to pursue his Ph D on Oak Forests of Pir Panjal Himalayas. Besides several research publications to his credit, he regularly contributes to local/national newspapers and magazines/journals on contemporary environmental concerns.

About the Book

The book, apparently designed in accordance with the UGC's prescribed course on Environmental Sciences, contains almost every bit of information on all aspects of environment including biodiversity issues, sustainable development, resource management, pollution, natural disasters, socio-environmental issues, etc. It is useful not only for college students but also for those appearing for various competitive examinations. Care has been taken to keep the book simple, illustrative and easily understandable for every section of the readers/students. It is structured in an attractive format with every unit consisting of various sections viz. **Abstract**, **Introduction**, **Details and Discussions** and **Recaps and Practices** for a better and holistic understanding of the subject. Every unit ends with a section consisting of **Facts in Brief** and **MCQs**. Full text of important **Acts** are included in addition to an immensely useful **Glossary** of terms often used in Environmental discourse

Highlights

- **Every unit consists of:**
  - **Abstract**
  - **Introduction**
  - **Detailed Discussions**
  - **Recaps and Summary**
  - **Practice questions**

- **Environmental Calendar**
- **Glossary of Terms**
- **Sample Question-papers**
- **Full text of important laws/acts**
- **Useful Bibliography**

Contents

Chapter 1

Understanding the Environment

Man is the product of his environment

Objectives

After going through this unit, we will be able to explain about:

- ✓ Concept, importance, types and components of environment
- ✓ Ecological balance in nature
- ✓ Environment and human health
- ✓ Environmental overexploitation and sustainable development
- ✓ Environmental science; its nature, scope and importance
- ✓ Need for Public Awareness

CHAPTER 1 UNDERSTANDING THE ENVIRONMENT

"We won't have a society if we destroy the environment"

Margaret Mead

ABSTRACT

The environmental complex is the natural integrated whole of all the physical systems on the earth. It consists of interacting components like air, water, soil, living organisms and set of various conditions and forces prevalent on the earth. The environment on the planet earth is believed to be unique in having a life-support-system which nowhere else in the universe is known to exist. The quality of environment is extremely important not only for humans but for the entire spectrum of the life on the earth. Man, being the supreme creature among all forms of life on the earth, possesses the capabilities to use and modify his surroundings or environment to suit his requirements. However overexploitation of environment by man has resulted in a chaotic situation in it. Irreparable depletion of natural resources, disturbances in natural ecosystems, loss of biodiversity and introduction of toxic and harmful pollutants in the environment have degraded the quality of environment. This state of affairs is bound to bring about major devastations on the planet. The realisation of what man has done to his environment has led to emergence of the concept of sustainable development. Sustainable development aims at attaining economic progress without compromising environmental considerations.

INTRODUCTION

The earth is the only known place in the universe where life exists. It is believed to be about 4.5 billion years old. Life originated on it about 3.5 billion years ago that is about one billion years after the earth came into existence. During this period there evolved an environment which supported life on it. It is this environmental complex which allowed and determined the existence, evolution and survival of innumerable forms of life on the earth. The environment includes everything that affects life. There are materials which are used by living organisms, climatic conditions which affect their survival and various forces which influence their well being. All these factors collectively and interactively form a life-suiting setup also called as life-support-system on the earth. Environment is thus a storehouse of various resources which are essential for life. Different components of environment interact within themselves and with living organisms present over there. These interactions have great bearing on organisms' survival and health. A good, safe and healthy environment is always a prerequisite condition for life on the earth. Its importance for human life is undisputed. Unfavourable changes happening in his environment are not good for his health.

Air, water, earth and biodiversity are the major parts of our environment. Our life heavily depends on these interrelated components of environment. Any disturbance to any of these components will badly affect entire environmental complex and thus all humanity will have to suffer. Human interventions in the natural environment have already caused a great deal of detrimental changes in the environmental complex. Global warming, ozone depletion, climatic change, etc are some of the problems caused mainly due to man's undue interferences in the environment. In addition to these problems of global scale, there are also some localised problems which affect particular regions where they originate. It is now urgently important to design and adopt effective strategies and measures at local, regional and global levels to save natural environment for our own survival and sustainable development.

DETAILS AND DISCUSSIONS

1.1. ENVIRONMENT

The term Environment has been derived from a French word '*environner*' which means to encircle or to surround. Everything, living or non-living, which surrounds us, forms our environment. Thus, the sum total of all the materials, forces and conditions that affect an individual's life is known as environment. All these materials, forces and conditions on the earth interact with one another and form a complex systems and sub-systems known as environmental complex. The integrated whole of physical and biological systems on the earth is called Life-support-system which enables life to exist and flourish.

1.1.1 Definition and Concept

United Nations Environment Programme (UNEP) defines environment as "***the whole outer physical and biological system in which man and other organisms live***".

P. Gisbert says, "***environment is anything immediately surrounding an object and exerting a direct influence on it***".

According to E. J. Ross, "***environment is an external force which influences us***".

As per Environment (Protection) Act of 1986, **environment** refers to the "***sum total of air, water and land and the interrelationships among themselves and also with the human beings, other living organisms or property.***"

Some other definitions of the term 'environment' given by eminent scientists or important environmental agencies are:

- 'A person's environment consists of the sum total of the stimulation which he receives from his conception until his death.' It can be concluded from the above definition that Environment comprises various types of forces such as physical, intellectual, economic, political, cultural, social, moral and emotional. Environment is the sum total of all the external forces, influences and conditions, which affect the life, nature, behaviour and the growth, development and maturation of living organisms'

  Boring

- 'The term environment is used to describe, in the aggregate, all the external forces, influences and conditions, which affect the life, nature, behaviour and the growth, development and maturity of living organisms.'

  Douglas and Holland

- 'All of the biotic and abiotic factors that act on an organism, population, or ecological community and influence its survival and development. Biotic factors include the organisms themselves, their food, and their interactions. Abiotic factors include such items as sunlight, soil, air, water, climate, and pollution. Organisms respond to changes in their environment by evolutionary adaptations in form and behaviour.'

  The American Heritage Science Dictionary

- 'The aggregate of surrounding things, conditions, or influences'

  dictionary.com

The place where an organism lives is known as the **habitat** of that organism. The habitat of an organism actually represents a particular set of environmental conditions suitable for its successful growth and survival. In its habitat an organism or group of organisms is surrounded and affected by other organisms or groups of organisms, materials, forces, conditions, etc. This whole of the factors which influence an organism is known as its

Environment. Man, like any other living organism on the earth, is also surrounded and affected by his environment. In fact, the main focus of environmental studies is man and the environment refers to what surrounds and affects man's life. But man cannot exist in isolation from other forms of life. These other forms of life including innumerable species of plants, animals and micro-organisms are part of man's environment and affect his life in many ways.

In its present form, the earth is like a round ball of solid mass with mean radius of 6371 km, equatorial circumference of 40077 km, total mass of 5976×1024g, and mean density of 5.517 g. cm-3. Life exists on its surface which is covered by landmass and oceans. Its surface is also surrounded from all sides by an aerial envelope. Soil, water and air together-with climatic and other natural conditions on the surface of the earth form the basic habitat for life.

The air, water, soil, all living and non-living things around us constitute our environment, which influences our lives. Thus from man's perspective, the whole outer physical and biological system in which man and other organisms live is the Environment. It is from the environment surrounding us that we get food to eat, water to drink, air to breathe and all other necessities of our daily lives. The Environment around us, therefore, constitutes a "Life Support System". We can generalize that everything which surrounds us forms a part of the 'environment'.

1.1.2. Importance of Environment

It is the environment which provides us a **life support system** which is vital for sustaining life on this planet. Environment is a storehouse of various resources which are essential for life. Different components of environment interact within themselves and with living organisms present over there. These interactions have great bearing on organisms' survival and health. A good, safe and healthy environment is always a prerequisite condition for life. Its importance for human life is undisputed. The unfavourable changes happening in his environment are not good for his health.

A living organism is a product of its **genotype** (genetic makeup) and **phenotype** (environment). Besides an organism's genetic make-up, its environment decides what type of individual it should become. Likewise it is environment which shapes the nature, distribution and prosperity of a population. A healthier and favourable environment guarantees a better and longer survival of an individual or a population.

We all share same environment on the earth. Every one irrespective of his age, sex, profession or place of living is affected by the environment he or she lives in and also affects his environment by his deeds. Any damage or disturbance caused to or happened in the environment is bound to affect all human beings equally. Air, water, earth and biodiversity are the major parts of our environment. Our life heavily depends on these interrelated components of environment. Any disturbance to any of these components will badly affect entire environmental complex and thus all humanity will have to suffer.

Human interventions in the natural environment have already caused a great deal of detrimental changes in the environmental complex. These changes are being seen as a tremendous threat to human existence itself. Global warming, ozone depletion, climatic change, etc are some of the problems resulted mainly due to man's undue interferences in the environment. These problems are of global scale. There are also some localised problems which affect particular regions where they originate. Protection of environment and its invaluable assets is indispensably important for our survival and sustainable development. Devising and adopting of effective strategies and measures to save environment at local, regional and global level is the need of hour.

1.1.3. Types of Environment

Though everything that surrounds a living organism is its environment and affects its life. However on the basis of proximity or nearness and the nature of the influences exerted on the organisms by the environment it can be of following types

a. **Micro-environment**: It refers to the immediate local surroundings of an organism.
b. **Macro-environment:** It refers to all the physical and biotic conditions that surround the organism externally. Microenvironment is merely a part of it.

Similarly on the basis of the composition or nature of the environmental components following types of environment can be enumerated.

a. **Terrestrial environment** where a major components of environment is land
b. **Aquatic environment** where water forms the major portion of an individual's environment
c. **Aerial environment** where air is the dominant environmental factor

1.2. COMPONENTS OF ENVIRONMENT

Another, more generalised, classification of various components of environment may be done in the following way.

a. Physical Environment or Physical component of environment
b. Biological environment or Biological component of environment
c. Social environment or Social component of environment

Physical environment refers to all abiotic factors or conditions like soil, minerals, temperature, light, rainfall, etc. It comprises of atmosphere, lithosphere and hydrosphere.

Biological environment includes all biotic factors or living forms like plants, animals and micro-organisms.

Social Environment includes an individual's social, economic and political condition wherein he lives. The moral, cultural and emotional forces influence the life and nature of individual behaviour.

Kurt Lewin adds another dimension to the components of environment. He says that although physical, biological and social environment are common to the individuals in a specific situation, yet every individual has his own **psychological environment**, in which he lives. Kurt Lewin has used the term '**life space**' for explaining psychological environment. The Psychological environment enables us to understand the personality of an individual. Both the person and his goals form psychological environment.

Why do we need atmosphere?

- All climatic changes occur in it.
- Water and other geochemical cycles need this component to complete
- Oxygen and other important gases which are required for life are present in it.
- It acts as a sink for pollutants and other materials.
- It protects life on the earth from harmful radiations.

Environment, however, is not a simple aggregate of the things surrounding us. It is very complex in its composition and functioning. It is comprised of the interacting systems of physical, biological and cultural elements which are interlinked both individually and collectively. It includes interactive physical materials, countless interdependent living beings, varying set of conditions and multitude of operative processes involving matter and energy and set of conditions. General physical laws govern the flow and fluctuations of matter and energy in the environment. All of its constituents work interdependently as a whole to provide it the required stability which is also pivotal for man's survival.

1.2.1 Physical Environment

The main physical components of the environment are:

a. The **Atmosphere** or the air

b. The **Hydrosphere** or the water

c. The **Lithosphere** or the rocks and the soil

d. The **Biosphere** or the living communities taken together. This component is sometimes studied as a separate type of environment and is known as **Biotic environment.**

1.2.1a The Atmosphere (*atmos=air; sphere=orbit, area*)

It refers to the mantle of gases which surround our planet. It is a complex mixture of a number of gases, water vapours and a variety of fine particulate material. It consists of about 5.15 x 10^{15} metric tons of gas which exerts a pressure of about 1 kg per sq.cm. on earth's crust. Most of these gases are compressed in the lowermost layer. Pressure decreases due to lowering concentration of gases as we move upward. It also acts as a blanket that makes life possible on the earth by regulating temperature, absorbing toxic gaseous wastes, filtering harmful solar rays and facilitating water cycle.

The thin layer of gases that envelops the Earth is held in place by the planet's gravity. Dry air consists of approximately 78% Nitrogen, 21% Oxygen, 1% Argon and other inert gases. Other gases present in earth's atmosphere are referred to as **trace gases**. Air also contains a variable amount of water vapor and suspensions of water droplets and ice crystals seen as clouds. Many natural substances such as dust, pollen, spores, volcanic ash, etc may also be present in tiny amounts in air. The ozone layer of the Earth's atmosphere plays an important role in depleting the amount of ultraviolet (UV) radiation that reaches the surface.

Table 1.1 Composition of earth's atmosphere

Atmospheric gases	Relative abundance(in percentage)
Nitrogen	78.08
Oxygen	20.95
Argon	00.93
Carbon dioxide	00.03
Neon	00.0018
Helium	00.00052
Methane	00.00015
Krypton	00.0001
Hydrogen	00.00005
Nitrous oxide	00.00005
Xenon	00.000009
Ozone	00.000007

Structure or layers of the atmosphere: The Atmosphere is divided into different layers which show different patterns of temperature.

Troposphere: It is the lower most region of atmosphere which is in contact with earth's surface is called troposphere. It extends upto a height of 20km above the equator and about 8km above the poles. The temperature in this layer drops with height and becomes as lower as -80°C at its upper limit. It is very important layer of the atmosphere and all weather changes take place in this layer. The **tropopause** is the boundary between the troposphere and stratosphere.

Stratosphere: This is the layer next to troposphere. It is about 30km in thickness and is very important zone of atmosphere as it contains the vital ozone layer. Temperature in this zone rises as with height from-80°C to 0°C at its upper extremity. This rise in temperature is due to the formation of Ozone from atomic and elemental Oxygen and absorption of the heat by the Ozone gas. The boundary between the stratosphere and mesosphere is called as the stratopause.

Mesosphere: This zone is about 40km in thickness. This region is characterized by a gradual decline in temperature from 0°C to -90°C at its upper end. It is the layer where most meteors burn up upon entering the atmosphere.

Thermosphere: The thermosphere extends upwards to a height of several hundred kilometres till the outermost limits of the earth's atmosphere. Temperature in this zone rises with height. The temperatures in the thermosphere may range from 500°K to 2000°K.

Ionosphere: Most of the constituents in this layer are in ionized form and temperature rises with height.

Exosphere: the outermost layer of the atmosphere which is very rarefied. It extends even beyond thermosphere.

Ozonosphere: The ozone layer is contained within the stratosphere. It is mainly located in the lower portion of the stratosphere from about 15–35 km (9.3–21.7 mi; 49,000–115,000 ft), though the thickness varies seasonally and geographically. About 90% of the ozone in our atmosphere is contained in the stratosphere.

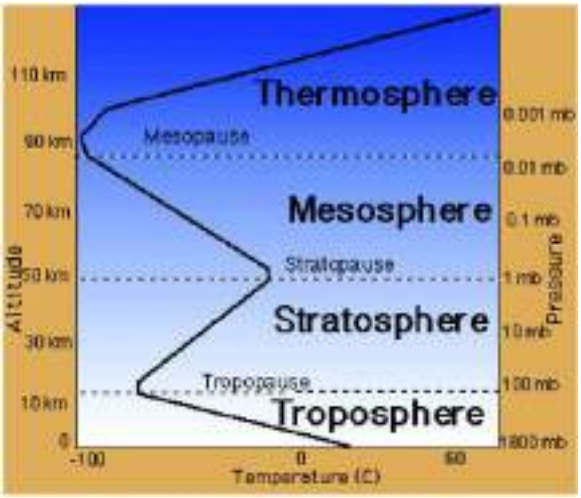


Fig. 1.1: Layering and temperature-pressure pattern in atmosphere (source: Teachertech.rice.edu)

1.2.1b The Hydrosphere (*hydro=water; sphere=domain, area*)

Hydrosphere refers to the total mass of water on the earth. The hydrosphere includes water that is on the surface of the planet, underground, and in the air. It, thus, can be liquid, vapour or ice. Liquid water on the earth exists on the surface in the form of oceans, lakes and rivers. It also exists below ground—as groundwater, in wells and aquifers. Water in vapour form is most visible as clouds and fog. The frozen part of Earth's hydrosphere is ice that is found in glaciers, ice caps and icebergs. This frozen part of the hydrosphere is also known as the **cryosphere**.

Water is an absolute essentiality of life on our planet. It is a natural resource of fundamental importance and its properties are very primarily useful for sustain life and life support system on the earth. Water is the medium in which all the biochemical process within a living organism occur. Outwards, it is the availability of water which determines the nature, composition and abundance of the terrestrial life. Climatic changes on the planet are primarily linked with water.

Why do we need Hydrosphere?

- Clean water for drinking (a metabolic requirement for living processes).
- Water for washing and cooking.
- Water used in agriculture and industry.
- Food resources from the sea, including fish, crustacean, sea weed, etc.
- Food from fresh water sources, including fish, crustacea and aquatic plants forms important part of human food.
- Water flowing down from mountain ranges is harnessed to generate electricity in hydroelectric projects.

Of the total estimated water about 95% is locked in the lithosphere and only about 5% is in free circulation. Out of this free water 99% is in oceans. Major portion of the earth's crust (about 71%) is occupied by water. Oceanic water is saline. Its salinity average salinity is around 35 parts per thousand (or 3.5%). In fact very meagre amount of fresh water is available for human use.

Both atmosphere and hydrosphere are always in motion. Water moves through the hydrosphere in a cycle known as **water** or **hydrologic cycle**. Water collects in clouds, and then falls to Earth in the form of rain or snow. This water collects in rivers, lakes and oceans. Then it evaporates into the atmosphere to start the cycle all over again.

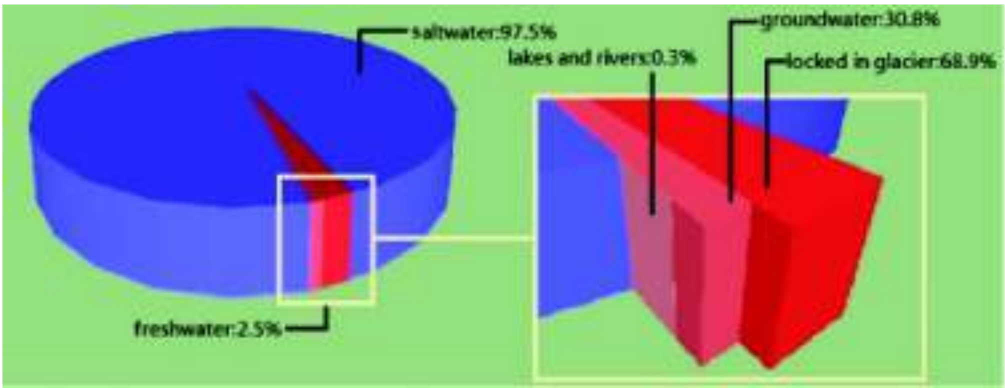


Fig. 1.2 Hydrospheric component of environment (Source: Wikimedia)

1.2.1c The Lithosphere (*lithos=roack;sphere=area, domain*)

The earth is divided into various regions or layers from its innermost centre to its outer surface. The innermost layer is called as **Core**, whereas middle region is named as **Mantle** and the outermost part of the earth is known as **Crust**.

The **lithosphere** refers to the solid, outer part of the earth. It includes the brittle upper portion of the mantle and the crust. It is bounded by the atmosphere above and the **asthenosphere** (a part of the upper mantle) below. The lithosphere is the most rigid of Earth's layers and extends from the surface of the earth to a depth of about 70–100 km. There are two types of lithosphere viz. **oceanic lithosphere** (which is under oceans) and **continental lithosphere** (which is open or terrestrial landmass). Entire lithosphere is composed of several crustal plates known as **tectonic plates** which keep floating on the molten material below them. Movements of these tectonic plates bring about various changes on earth's surface such as earthquakes, volcanic activity and continental drifts.

Why do we need Lithosphere?

- It provides the basic stratum for various forms of terrestrial life.
- Soil, the basis for agriculture to provide us with food.
- Stone, sand and gravel, used for construction.
- Micronutrients in soil, essential for plant growth.
- Microscopic flora, small soil fauna and fungi in soil, important living organisms of the lithosphere, which break down plant litter as well as animal wastes to provide nutrients for plants.
- A large number of minerals on which we heavily depend are obtained from the earth.
- Oil, coal and gas, extracted from underground sources. It provides power for vehicles, agricultural machinery, industry, and for our homes.

Generally speaking, by lithosphere we mean the rocks and the soil derived from the crustal rocks. There are about a dozens of elements which mainly constitute the lithosphere i.e earth's crust. Rocks form the basis of the lithosphere and soil is formed by the disintegration of these rocks. Three types of rocks are found on the earth's surface.

Igneous Rocks (*igneous= eruptive, fiery*): They are formed by the cooling and solidification of the molten rock material called Magma. All other types of rocks are formed from this type. Examples include: Basalts, Diorite, etc.

Sedimentary Rocks (*sediment= deposit*): They develop as a result of gradual accumulation and hardening of mineral particles brought together by winds, water or other agencies. These rocks form distinct layers during the process of their formation. Examples include: Sandstone, Shale, Limestone, etc.

Metamorphic Rocks (*metamorphosis=transformation*): These rocks are formed as a result of metamorphosis of igneous and sedimentary rocks. This transformation occurs under high pressure and extreme heat. Examples include Schist, Slate, Marble, Quartizite etc.

1.2.1d Soil

Soil is the most important feature of lithosphere from life's point of view. It is the soil which provides substratum to most of the life forms on the earth. It is the soil that provides support, home, water and nutrients to living organisms**.** It forms the topmost layer of earth's crust and is a mixture of many solids, liquids and gaseous substances.

Soil is formed through the interactions among the weathering of underlying rock, the climate, plants and the activities of millions of insects and earthworms etc. All these physical, chemical and the biological activities build up the soil layer over a long period of time. As a result of various processes (i.e. physical, chemical and biological) occurring within the soil of a particular place, a mature soil develops a definite soil structure which is characteristic of the environmental conditions of that place. It has both the living and non-living matter like mineral particles, decaying plant remains and insects living together with countless bacteria on its organic matter. In addition soil holds water and air in its pore. The combination of all these nutrients in the body of soil provides the plants food for their growth. When the plants die, the nutrients absorbed by them again become part of the soil system as they are decomposed by soil biota into simpler substances.

Soils are structurally and characteristically composed of five major components: mineral materials, organic matter, water, air, and soil organisms. The composition and proportion of these components together with the environmental conditions determine the characteristics of soil.

Soil profile

Starting from the underlying rock which supplies the parent material for the formation of soil, a series of layers are developed. Each layer is called a soil horizon and the sequence of horizons is termed as the **soil profile**. There are five main types of horizons in soil. These are denoted as **O**, **A**, **B, C** and **R** horizons

O-horizon is the topmost portion of soil**.** It consists of organic matter and is commonly found in forest soils. It is further subdivided into:

O1: Organic horizon wherein the original forms of plant and animals residues can be recognized by naked eye.

O2: Here the original plant and animal forms cannot be so distinguished.

A-horizon (eluviatial zone): This is mineral horizon, which lies at or near the surface and is recognized as zones of maximum leaching or **eluviation**. It is further divided into A1, A2 and A3 components.

B-horizon (**illuvial zone**): It is the layer below the A layers. In this layer maximum accumulation of **iron** and **aluminum oxide** and **silicate clays** occurs. The B Horizon is sometimes also referred to as **subsoil.** It is further divisible in B1, B2 and B3 layers.

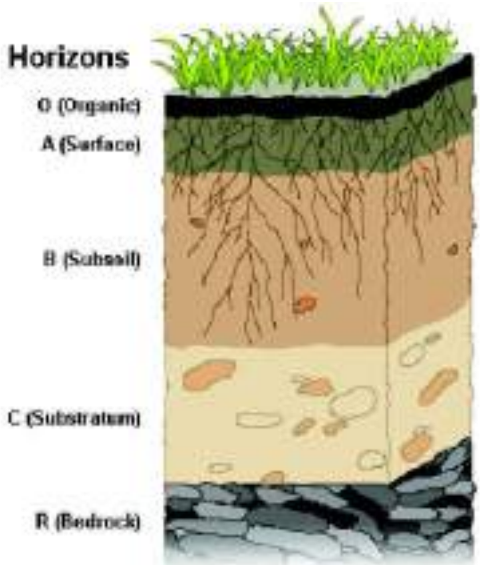


Fig. 1.2. Soil Profile (Kaushak, 2008)

C-horizon: It is mineral layer beneath the B-horizon. This layer lacks any of the characteristics of the horizons above it.

R-horizon: It represents bedrock from which other horizons may have been originated.

Soil texture

It refers to the relative proportion of particles of various sizes in a given soil. Soil texture is, thus, determined by the relative proportions of sand, silt, and clay particles in the soil. For this purpose, soil particles are classified into different size (diameter in mm) categories:

Name of the particle	Diameter range (mm)
Clay	Less than 0.002
Silt	0.002-0.02
Fine sand	0.02-0.20
Coarse sand	0.20-2.0
Stones and Gravel	Above 2.0

Soil texture directly influences the soil-water relationships, aeration and root penetration through its relationship with inter-particle pore space. Indirectly it also affects the nutritional status of soil. Sandy soils are nutrient-deficient due to high porosity.

Other characteristics of soil include its density, porosity, moisture content, temperature, air, pH, biota, fertility, colour, water retention capacity, ion exchange capacity, etc. These characteristic features vary from soil to soil.

Soil types

Soils are classified in various groups or orders on the bases of different considerations. Depending upon the climatic and vegetational considerations, soil can be classified into the following groups:

- **Podzolic soil is found** in humid temperate climate, under forest vegetation.
- **Latosolic soil** develops in humid tropical or semitropical-forested regions.
- **Chernozemic soil** occurs in humid to semi-arid temperate climatic conditions under grasses.
- **Desertic soil** is found in arid climatic conditions.
- **Mountain soil** occurs in hilly regions under colder climates.
- **Tundra soil** develops in colder regions and under vegetation such as lichens, mosses, herbs and shrubs.
- **An alluvial soil** is formed as a result of deposition by the rivers and streams and lacks well-developed profile. They support luxuriant growth of vegetation.
- **Saline soil** occurs in the dry climates where rapid evaporation of water results in surface deposition.

1.2.2. Biological Environment or Biosphere (*bio=life; sphere=area, domain*)

It refers to the zone of life on Earth. It, in fact, relates to the living organisms which are part of an individual's environment or surroundings. Every living organism is surrounded by other living organisms which are part of its environment. Just like physical factors of environment, the other living organisms present in surroundings also affect the life and survival of an individual. Man is surrounded by billions of other living organisms which play very important role in his life. Plants, animals and microorganisms present on the earth affect man's life in innumerable ways.

Biosphere is postulated to have evolved, at least some 3.5 billion years ago. The term "biosphere" was coined by geologist **Eduard Suess** in 1875, which he defined as '**the place on Earth's surface where life dwells'**. All the living creatures present on the earth are collectively known as Biosphere. It is the living part of our environment or the zone of life on earth. It is also known as the sum total of life on the earth. However it cannot exist without a life support system which is provided by a structural and functional togetherness of the other three environmental components discussed above. Owing to diverse environmental conditions on earth, life shows a great deal of variety. There are millions of species of living organisms belonging to a large number of families and taxonomic groups. Some estimates say there are 15,95,225 species present in the biosphere. However, estimates of actual number of species present vary widely due to incomplete data in this regard. Wilson in 1992 put the total number of living species in a range of 10 million to 50 million. Till now only about 1.5 million living and 300,000 fossil species have been actually described and given scientific names.

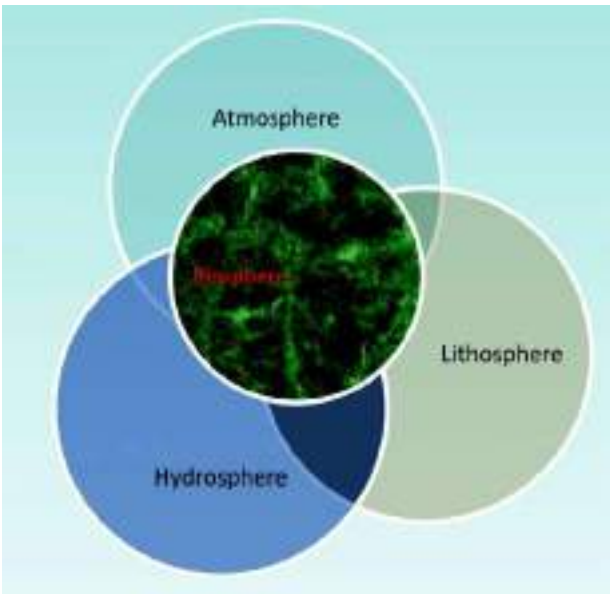


Fig. 1.3. All the components of environment are, interlinked, interactive, interdependent and overlapping (Jazib, 2016)

Biological environment can further be classified in various ways. Depending upon the nature of organisms, they can be classified as **plants, animals, bacteria, fungi, viruses**, etc. On the basis of their role and status in the ecosystem, they can be categorised as **producers** (green plants), **consumers** (animals) and **decomposers**.

1.2.3. Social Environment

Man is said to be a social animal. He lives in a highly advanced form of society. This feature of social living adds another dimension to his environment. Social environment refers to the immediate social setting in which people live. It includes the cultural, educational, political and other social aspects of a society where an individual lives. It also includes the aspects of social interaction including its products such as beliefs, attitudes, traditions, cultural values, etc. Various aspects of a man's social living affect his individuality, health, perceptions and overall welfare. Education level, socioeconomic status, awareness level, social interactions and moral values prevalent in a society collectively form the social environment of an individual. Various factors of social environment of an individual may be enlisted as below:

- Culture and history
- Standards of living
- Education and awareness
- Socioeconomic conditions
- Social stability
- Moral values in the society
- Political structure
- Economic system
- Technological application
- Availability of basic amenities

All these social factors have great bearing on general personality, individuality, health and progress of an individual in the society.

A good social environment is always in the benefit of overall well being of the individuals and the society. A social environment characterised by an educated society will produce good citizens. An individual living in a morally sound environment is bound to prove a good human being. On the other hand a society full of crises is less probable to have good impacts on individuals.

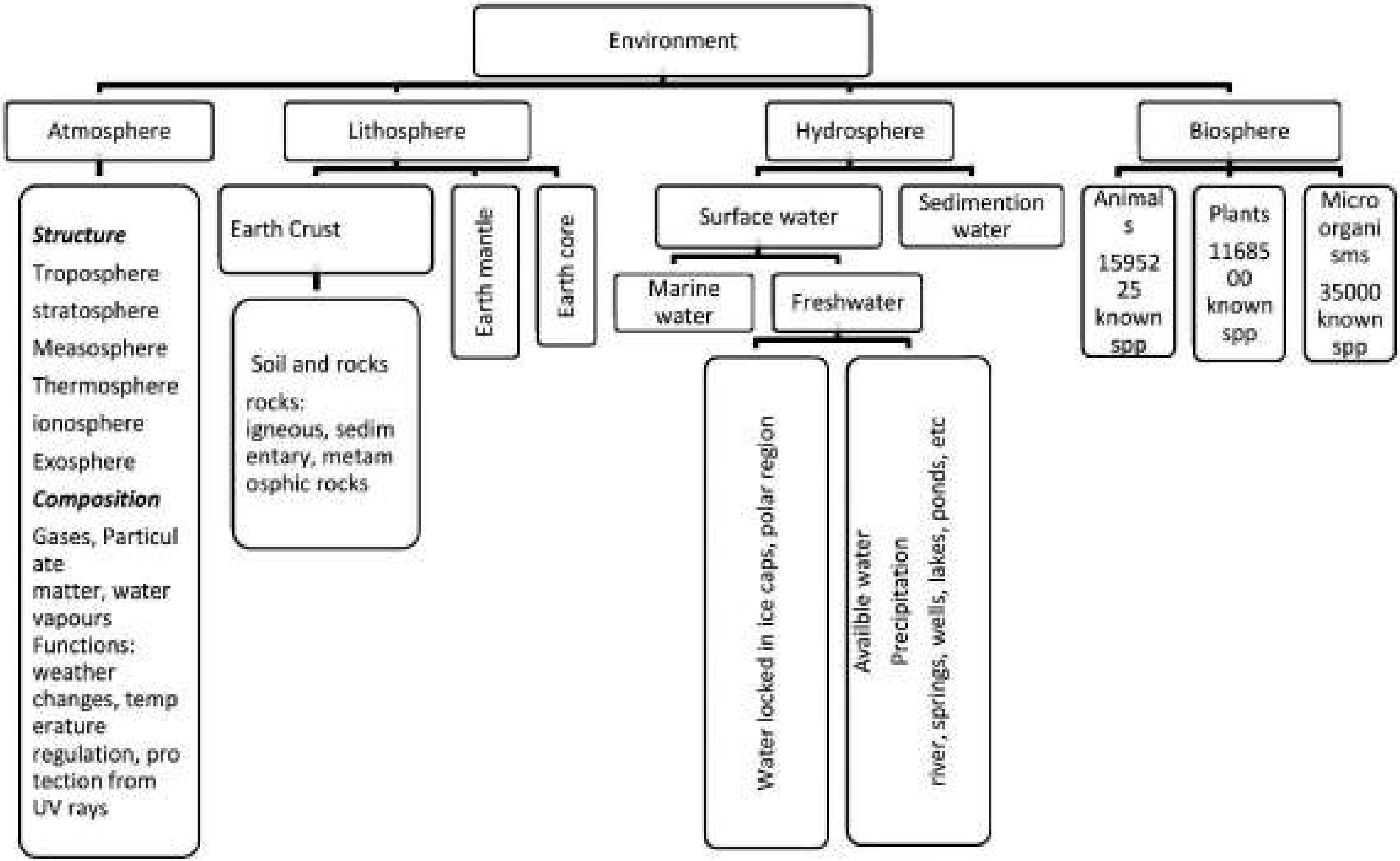


Fig. 1.4. Summarized sketch of various physical components of environment (Jazib, 2012)

1.3. ECOLOGICAL BALANCE IN NATURE

Earth is the only planet known to have life on it. The life exists here due to presence of liquid water and a favourable environment also called as life-support-system. This life support system is in a perfectly balanced state. Everything on the earth is related to everything else on it. Physical and biological components of environment on the earth interact with one another in a very systematic manner and thus keep the system running smoothly. Any unit of such a system of interacting and interrelated complex of physical and biological systems is called as ecological system or simply ecosystem. A pond, a river, a forest, a sea and even entire earth is an example of an ecosystem. The balance maintained in the nature (ecosystem) due to a perfect relationship between its various components is called as ecological balance. It is also defined as," a state of dynamic equilibrium within a community of organisms in which genetic, species, and ecosystem diversity remain relatively stable except gradual changes through succession".

As in a human society there are various jobs performed by different professionals to keep it stable and running. A farmer, a doctor, a teacher, a sweeper, etc. everyone has a specific work to perform. This systematic arrangement of responsibilities keeps the society stable and it functions properly. Removal of any of these professionals may result in chaotic situation. In a similar way there are various components of ecosystem in nature. Every component performs a specific function to keep the ecosystem or nature stable and functioning. There are hundreds of plants and animal species in nature and every single species is related with other ones and occupies a special space and status in natural setup. Predator species keep the population of prey species under control. Some insect species play pivotal role in pollination of tree species. Decomposers act upon dead and decaying organisms and keep the environs clean. Thus all forms of life have specific roles to keep the ecological balance maintained in nature. Removal of even a single species from this ecological setup or arrangement may cause detrimental effects in natural balance and normal functioning of ecosystems.

Changes do occur in an ecosystem but in a controlled manner so that the overall balance does not disturb. Nature has capability to bear and correct minor disturbances caused due to unwanted changes brought about in ecosystems by man or natural factors. However when changes or disturbances from external factors exceed restoring capacity of nature the ecological balance gets hugely disturbed. This disturbance in ecological balance of nature ultimately leads to devastation in it. For example when due to hunting the population of a predator species gets reduced to very low number, the population of a prey species will increase greatly. This will increase the demand of food for prey species whose population has increased by many times than usual. As there would not be sufficient food available to prey species, the shortage of food will lead to mass mortality of prey species. This will disturb the whole balance of nature. Similarly unnatural removal or extinction of any species from nature will lead to ecological disturbances as no other species will be able to serve the role of extinct species. This may, in turn, result in a chain reaction of species depletion.

Common causes of disturbance in ecological balance of nature include:

- Introduction of new species
- Sudden death of some species
- Natural hazards
- Overexploitation of nature by man
- Man-made disasters which results in unfavourable conditions for certain species
- Environmental pollution leads to biodiversity loss

Ecological balance in nature is maintained through a well knit system of various environmental or ecological components. All forms of life are arranged in an interdependent manner on the earth. From a small ecosystem like pond to the biggest ecosystem comprising of the entire earth (called **ecosphere**) living organisms are organised in a way that brings and maintains stability.

James Lovelock proposed a theory known as **Gaia hypothesis** which explains that living organisms interact with their abiotic surroundings on the earth to form a self regulating system.

1.4. ENVIRONMENT AND HUMAN HEALTH

A safe and healthy environment is indispensable for human health. It is the environment from where we, like every living organism, derive all our requirements. Every component of environment plays role in our survival and development in one way or the other.

World Health Organisation (WHO) defines health as "a state of complete physical, mental and social well-being". Human health is, in general, influenced by biological, nutritional, chemical, psychological and social factors present in the environment where one lives. These factors may cause harmful effects on human body or mind and the resultant condition is called a disease.

A healthy environment means an environment which is safer and suitable for human growth and development. It must be free from any disturbances and pollution which may have detrimental effects on human health. Generally human health depends upon:

- Genetic factors
- Availability of basic facilities
- Availability of food and nutrient requirements
- Type, extent and utilization pattern of available natural resources
- Hygiene and sanitation system
- Awareness and education about health related issues
- Healthcare system

Most of the health related factors listed above are, directly or indirectly, linked with environment. Natural resources (such as forest, land, food, water etc) and hygiene belong to environment which we live. Physical conditions like temperature, rainfall, wind, etc directly affect human health besides shaping general environmental complex. Biosphere or living component of our environment is significant in determining our health by fulfilling our basic requirements of varied nature. Social environment is equally important in shaping our mental and physical health.

It is environment or its components through which pathogens spread from a place to another. Pathogens survive in unhygienic conditions and unhealthy environment. Various toxic substances or pollutants which enter environment cause serious health problems among population which live in that environment.

Environmental Health is now a popular term recognised to denote a branch of Public Health that deals with environmental aspects and issues which may directly affect human health. It is concerned with various aspects of natural or built environment for the benefit of human health. World Health Organisation (WHO) defines Environmental Health as "those aspects of human health and disease that are determined by environmental factors". It covers the assessment and control of those environmental factors which can potentially affect human health. According to WHO more than 30% of diseases in children are caused due to environmental exposures. These diseases can effectively be prevented by keeping the environment healthier. Better environment management greatly helps in reducing disease outbreak. Better hygienic conditions, proper storage of food and water, use of environmentally clean fuels, control of environmental pollution and adoption of preventive measures surely reduces the risks of health related problems.

Environmental factors that can generally affect human health in one way or the other include:

A. **Physical factors**: Various physical characteristics of the environment play crucial role in general human health and occurrence or spread of diseases. Temperature, humidity, precipitation, etc affect human health in both positive and negative ways. In tropical regions where temperature and humidity is higher disease causing organisms flourish more commonly. Floods and droughts also affect human health. In such stressful conditions man becomes more susceptible to diseases. The general physic-chemical setup, housing, urban developmental aspect, land use and transport systems at the place where one lives and the basic facilities available considerably influence human health and occurrence of diseases.

B. **Biological agents**: It refers to the pathogens or disease causing organisms present in the environment. They survive and reproduce in environmental components such as air, water and soil and pose great threat to human health. Bacteria, viruses and other microorganisms cause infectious diseases in humans and other animals. Water and food borne diseases are particularly common in developing countries and are responsible for large number of deaths every year. They, particularly bacteria, cause food poisoning by adding poisonous chemicals in the contaminated food. Gastrointestinal diseases such as cholera, diarrhoea, dysentery, etc and respiratory diseases such as influenza, pneumonia and tuberculosis are the infectious diseases caused by microorganisms present in our immediate environment under unhygienic conditions.

C. Chemicals: Human activities have released large number of chemicals in the environment. These chemicals released from industrial activities, transportation or domestic appliances are detrimental for health when come into contact with human body. High levels of these chemicals cause innumerable environmental and health problems for humans. Many of these pollutants are responsible for global warming (such as CO_2) and ozone depletion (such as CFCs) which indirectly cause human health problems. Others are toxic in nature and causes serious health problems in humans. Carcinogenic chemicals cause cancer where as many others cause various types of allergies in skin and respiratory system. There are chemicals called neurotoxins which impact nervous system. Pesticides such as DDT, endosulphan, aldrin, etc enter food chain through which it reaches human body and affects it adversely. Heavy metals like Lead, Mercury and Arsenic are introduced into the environment by industrial and other wastes. These substances are toxic and causes various ailments when enter human body along with food or water. A disease called '**Minmata disease'** caused deaths and permanent paralysis of hundreds of people in Japan due to consumption of Methyl Mercury through fish obtained from Minmata water body. Excess of Flouride consumed through contaminated water causes **Fluorosis** –a disease of bones and teeth. Use of Arsenic contaminated ground water has caused different abnormalities in humans in some areas of West Bengal and Punjab. Excess consumption of nitrate causes **blue baby syndrome. Toxicology** is the branch of pharmacology that deals with the nature, effects and treatments of poisons or toxic chemicals present in the environment.

D. Radiations: Radiations are the waves of energy that travels and spread all around in our environment. These radiations are useful as well harmful for us. Examples include visible light, radio waves, microwaves, infrared and ultraviolet lights, X-rays, and gamma-rays, etc. Radiation pollution refers to the increase in the natural radiation levels in our surroundings due to human activities. It is said that in today's world about 20% of radiation we are exposed to is due to human activities. The human activities that may release radiation involve activities with radioactive materials such as mining, handling and processing of radioactive materials, handling and storage of radioactive waste, as well as the use of radioactive reactions to generate energy (nuclear power plants), along the use of radiation in medicine (e.g. X-Rays) and research. Microwaves, cell phones, radio transmitters, wireless devices, computers, and other common commodities of today's life are also the sources of various types of radiations. Radioactive radiations are however believed to be the most harmful radiations. Radioactive substances are present in nature. They undergo natural radioactive decay in which unstable isotopes release high energy radiations such as gamma rays (high energy electromagnetic radiation) or ionization particles i.e. alpha particles and beta particles. The alpha particles are fast moving positively charged particles whereas beta particles are high speed negatively charged electrons. Alpha particles can be interrupted by a sheet of paper while beta particles can be blocked by a piece of wood or a few millimeters of aluminium sheet. The gamma rays can pass through paper and wood but can be stopped by concrete wall, lead slabs or water.These radiations can affect living organisms by causing harmful changes in the body cells or genetic makeup.

i. Genetic damage is caused by radiations, which induce mutations in the DNA, thereby affecting genes and chromosomes. The damage is often seen in the off springs and may be transmitted up to several generations.

ii. Somatic damage includes burns, miscarriages, eye cataract and cancer of bone, thyroid, breast, lungs and skin. Many scientists are of the view that due to body's ability to repair some of the damages, the adverse effects of radiations are observed beyond a threshold level. However, the other group believes that even a small dose of radiations over a period of time may cause adverse effects. They believe that the permissible limits of ionising radiations should be further reduced.

Damage caused by different types of radiations depends on the penetration power and the presence of the source inside or outside the body. Alpha particles lack penetration power but they have more energy than beta. They will be, therefore, dangerous when they enter the body by inhalation or through food. Alpha particles cannot penetrate the skin to reach internal organs whereas beta particles can damage the internal organs. Greater threat is posed by radioisotopes with intermediate half-lives as they have long time to find entry inside the human body.

Radioisotopes enter the environment during mining of uranium. The radioactivity in the earth.s crust enters the crops grown there and ultimately in human beings. Radionuclides enter the water bodies or the groundwater coming in contact with the contaminated soil or rock. Radioactive iodine (I131) accumulates in thyroid gland and causes cancer. Similarly, strontium-90 accumulates in the bones and causes leukemia or cancer of bone marrow.

E. Noise: Unwanted sound in the environment causes various physiological and psychological problems. Long-time exposure to high levels of noise results in hearing loss. It also causes sleeplessness, heart problems and other psychological issues such as mental fatigue, annoyance, lack of concentration, etc.

1.5. OVER-EXPLOITATION OF ENVIRONMENT AND SUSTAINABLE DEVELOPMENT

Environment is a store house of all the materials and the favourable conditions and forces vital for life. There are millions of species of living organisms on the earth. Man (*Homo sapiens*) has appeared quite late (about 40.000 years ago) during the process of evolution on this 4.6 billion years old earth. However, after emerging on the scene, this late comer has captured the key role on the planet. Owing to his unique capabilities, man has become the master of the show. He possesses the capability to change, modify and exploit his environment to suit his needs. He has invented the means and tools to control his environment and use the natural resources present therein.

'Initially when the human population was small and the level of scientific and technological development was low, the extent to which human beings could interfere with the ecosystem was limited and the ecosystem was able to sustain the effect of human intervention. But with the growth of human population, the demands as well as interference with the environment have increased many folds. Scientific and technological advancement and human ingenuity have all been extensively used for exploitation of the natural resources. The ecological balance has been badly disturbed and the ecosystem is not able to cope up with the drastic changes caused by the activities of human being. Anthropogenic activities (caused by human actions) have started polluting and degrading the environment' (Kaushak, 2008).

Man's unjustifiable greed for material progress has ultimately led to a chaotic situation in the environment. Owing to highly sophisticated technologies available with man and his ever expanding knowledge of surroundings, man has left nothing untouched in the natural environment. He has utilised wildlife and biodiversity leading to its depletion. He has cleared forests to increase agricultural production and to build concrete structures. He has dig earth to excavate minerals and fossil fuels. He has polluted earth, water and air with toxic materials.

Declining natural resources, drastically raised levels of green house gases, an unusual warming of the planet, melting of polar ice caps, rising of sea level, harsher weather conditions, thinning of ozone shield, deteriorating soils, fresh-water becoming a scarce commodity and disappearance of species after species, etc are the distressing indicators of the present environmental situation on our planet.

In crazy race of economic progress man has, inconsiderately, sacrificed what actually formed the basis for his economic progression and advancements. Acquiring of sophisticated luxuries has cost him the very basics of life. For these undreamed comforts he has paid in terms of pure air, pure water and pure land. With aerial and space travelling facilities, air-conditioned abodes, sky-high crop productivities, fingertip-based technologies, etc we have also with us toxic water, poisoned air and contaminated land.

Summarisingly, it can be generalised that at present humanity is facing with serious and innumerable environmental problems. There is:

- Pollution of air, water and land
- Climatic changes and global warming
- Depletion of wildlife and biodiversity
- Waste disposal problem
- Dwindling natural resources
- Shortage of food for humans
- Degradation of land and desertification
- Nuclear hazards

If these eco-crises confronting the humanity are to be reversed or tackled with, every citizen of the world needs to be alerted. Humanity has to come closer to act rationally and wisely for the sake of its own survival. The attitudinal change has to be invoked among individuals and the society. Every individual has to qualify, in his thoughts and actions, for the global citizenship. He has to act constructively, at his lowest level and in his individual capacity, for himself and for the humanity. Planting a tree, avoiding wastage, being kind to nature, sticking to ethics, adopting simplicity, etc. are the simplest but principally the surest eco-friendly and humanity-saving activities.

Of course there is no escape to industrialization if any state has to grow economically. But it should be achieved through optimal, judicious and sensible utilization of natural resources and minimum waste generation. No doubt we have to progress in agricultural sector but should not attain it by clearing the remaining portions of forests and altering the biogeochemical cycles. We must make use of biofertilizers and biofriendly techniques in our agriculture. Install primary infrastructures and power generation plants but compensate be-fittingly (by planting more trees) for every single tree felled. We need to revise our developmental approach to make it more responsive and beneficial in real sense. Environmental Impact Assessment should be carried out well in advance for every proposed (developmental) project, and the recommendations based on it be followed strictly and honestly. Environment protection laws need to be formulated and implemented in letter and spirit. Encouraging environment friendly technologies (at user as well as manufacturer's levels), reviving safer traditional technologies and incorporating them in developmental processes may help reorient present developmental approaches. Adopting safety measures, following environment ethics, shunning unlimited greed for materialistic gains, etc. are obligatory for a sustainable development

1.5.1. Sustainable Development

Generally development means economic progress. But this economic progress is often achived at the cost of long term losses. These losses include environmental implications and depletion of resources which will not be available for future generations.

Sustainable development is defined as, 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'.

Although the fears about such unsustainable growth and development started in 1970s, yet a clear discussion on sustainable development emerged on an international level in 1992, in the UN Conference on Environment and Development (UNCED), popularly known as **The Earth Summit**, held at Rio de Janeiro, Brazil. The Rio Declaration aims at "a new and equitable global partnership through the creation of new levels of cooperation among states." Out of its five significant agreements **Agenda-21** proposes a global programme of action on sustainable development in social, economic and political context for the 21^{st} Century (Kaushak and Kaushak, 2006).

Sustainable development aims at including the environmental or ecological aspects in the general developmental approach. Sustainable development is described in terms of three dimensions, which include "economic, environmental and social" aspects. Some expets adds another fourth dimension to it that is 'culture or governance.

From environmental point of view development is said to be sustainable if it does not harm environment and natural ecosystems. There are some general means and indicators of sustainable development such as:

- Consideration of possible environmental impacts due to developmental projects
- No or minimum damage to environment and natural ecosystems
- Use of appropriate and eco-friendly technology
- Adoption of **Reuse, Recycle** and **Reduce** (**3Rs**) approach
- Minimum or no waste generation
- Raising environmental awareness and education

1.6. ENVIRONMENTAL SCIENCE

The study which covers different aspects of environment is known as Environmental science. It is an applied science which seeks practical answers to make human civilization sustainable on the earth's finite resources. Environmental Science adopts a multidisciplinary approach to study and deal the environmental issues which have direct relevance with mankind. It involves biology, geology, chemistry, physics, engineering, sociology, health, anthropology, economics, statistics, computer applications and philosophy which are brought together for a better and proper understanding of natural environment and human connection with it.

1.6.1. Environmental Sciences: Definition

Environmental Science is defined as the science that deals with different aspects of environment and emphasise on the maintenance of its quality involving conservation of biotic and abiotic resources. It deals with all the environmental issues ranging from health and hygiene to ozone depletion and climatic changes.

The National Center for Education Statistics in the United States defines an academic program in environmental science as follows:

A program that focuses on the application of biological, chemical, and physical principles to the study of the physical environment and the solution of environmental problems, including subjects such as abating or controlling environmental pollution and degradation; the interaction between human society and the natural environment; and natural resources management.

1.6.2. Components of Environmental Sciences

A. Ecology
B. Environmental Studies
C. Environmental Engineering
D. Environmental Ethics
E. Conservation Biology
F. Environmental Chemistry
G. Environmental Geography
H. Environmental Sociology
I. Environmental Policy and Law
J. Toxicology
K. Limnology
L. Environmental Hydrology
M. Wildlife

> **"If you plan for one year, plant rice, if you plan for ten years, plant trees and if you plan hundred years, educate people"**
> **.......................Chinese proverb**

In common usage, "environmental science" and "ecology" are often used interchangeably, but technically, ecology refers only to the study of organisms and their interactions with each other and their environment. Ecology could be considered a subset of environmental science, which also could involve purely chemical or public health issues (for example) ecologists would be unlikely to study. In practice, there is considerable overlap between the work of ecologists and other environmental scientists. Related areas of study include environmental studies and environmental engineering. Environmental studies incorporates more of the social sciences for understanding human relationships, perceptions and policies towards the environment. Environmental engineering focuses on design and technology for improving environmental quality in every aspect. Environmental scientists work on subjects like the understanding of earth processes, evaluating alternative energy systems, pollution control and mitigation, natural resource management, and the effects of global climate change. Environmental issues almost always include an interaction of physical, chemical, and biological processes. Environmental scientists bring a systems approach to the analysis of environmental problems. Key elements of an effective environmental scientist include the ability to relate space, and time relationships as well as quantitative analysis.

Coinage of another term, "Environmentology" for what is discussed under environmental science can be suggested here for a consideration by the academicians.

1.6.3. Multidisciplinary Nature of Environmental Sciences

Environmental science is a multidisciplinary academic field that integrates physical, biological and information sciences (including but not limited to ecology, biology, physics, chemistry, zoology, mineralogy, oceanology, limnology, soil science, geology, atmospheric science, geography and geology) the study of the environment, and the solution of environmental problems. The science of environment makes use of the knowledge and the tools of these physical, social and biological sciences in its investigative domain.

To understand different aspects of our environment we need to study different subjects such geology, geography, biology, physics. To assess and understand human relationship with nature we apply the knowledge and skills in various subjects such as economics, anthropology, sociology etc. To investigate human impacts on his environment knowledge and techniques of yet some other disciplines are to be employed.

In common usage, "environmental science" and "ecology" are often used interchangeably, but technically, ecology refers only to the study of organisms and their interactions with each other and with their environment. Ecology could be considered a subset of environmental science, which also could involve purely chemical or public health issues (for example) ecologists would be unlikely to study. In practice, there is considerable overlap between the work of ecologists and other environmental scientists.

1.6.4 Scope of Environmental Science

Environmental Sciences is concerned with human welfare. Its main objectives are sustainability and better future. It deals with a varied array of issues facing mankind at local, regional and global levels. It attempts to understand the global environmental problems and suggest corrective measures at local and global levels. It prepares people for global citizenship as the same environment on the earth is shared by the all; and the same stands true for global issues related to environment as the entire humanity has to face them. It can be put as:

- Environmental Science is global in its scope of studies as it deals with issues at global level.
- It deals with every general problem that mankind confronts and thus covers entire domain of human activities. Its scope, therefore, encompasses the whole humanity.
- Environmental issues are not of a particular single type. They are varied in their origin, nature and extent. This necessitates the introduction of environmental science

into the curricula of other subjects of studies so that the knowledge and information can be used in constructive manner for the betterment of the humanity. Environmental Science has enough scope to be taught with any stream of sciences

In other words environmental science includes and attempts to deal with almost all the issues relevant to general welfare of humanity at local, national or international level. Some of the major issues encompassed under environmental science include:

- Global warming
- Biodiversity decline
- Pollutions
- Population explosion
- Natural resources decline
- Soil degradation
- Natural disasters
- Ozone depletion

1.6.4. Importance of Environmental Science

The importance of Environmental Studies cannot be disputed. The need for sustainable development is a key to the future of mankind. The degradation of our environment is linked to continuing problems of pollution, loss of forest, solid waste disposal, issues related to economic productivity and national as well as ecological security. The increasing levels of global warming, the depletion of the ozone layer and a serious loss of biodiversity have also made everyone aware of growing environmental concerns. The United Nations Conference on Environment and Development held in Rio De Janero in 1992, and the World Summit on Sustainable Development at Zoharbex in 2002 have drawn the attention of people around the globe to the developing condition of our environment. It is clear that no citizen of the earth can afford to be ignorant of environmental issues. Environmental management has become a part of the health care sector. Managing environmental hazards and preventing possible disasters has become an urgent need.

Human beings have been interested in ecology since the beginning of civilization. Even our ancient scriptures have included practices and values related with environmental conservation. It is now even more critical than ever before for mankind as a whole to have a clear understanding of environmental concerns and to follow sustainable development practices.

India is rich in biodiversity which provides various resources for people. It is also the basis for biotechnological development. Only about 1.8 million living organisms have been described and named globally. Still many more remain to be identified and described. Attempts are made to conserve them in ex-situ and in-situ situation. Intellectual Property Rights (IPRs) have become important in a biodiversity rich country like India to protect microbes, plants and animals that have useful genetic properties. Destruction of habitats, over use of energy resources and environmental pollution have been found to be responsible for the loss of a large number of life forms. It is feared that a large proportion of life on earth may get wiped out in the near future.

In spite of the developing status of the environment, the formal study of environment has so far not received adequate attention in our academic performances. Recognisation thus the Hon'ble Supreme Court directed the UGC to introduce a basic course on environment for every student. Accordingly the matter was considered by the UGC and it was decided that a six months compulsory core module course in environmental studies may be prepared and compulsorily implemented in all the Universities/ Colleges in India. (Bharucha, 2006).

1.6.5. Nature of Environmental Science: Art or Science?

Environmental science is an art as well as a science. Art is the doing of the things in a beautiful and proper manner and science is the understanding of the things in their proper context. A painter for example who paints beautiful pictures is an artist. He may not be aware of the chemical nature of the colours and their chemical reactions. A physicist or chemist who studies the nature and reactions of various colors is scientist. An environment scientist studies the environmental phenomenon in their originality and in analytical ways. But he simultaneously applies this knowledge in artistic manner for the improvement of degrading environment.

1.7. NEED FOR PUBLIC AWARENESS

The contemporary era is characterized by the high degree of general awareness among the citizens. The ever expanding knowledge in any domain of sciences, no more remains an entity restricted to the few elites. Be it any realm of knowledge, today it is readily available to everyone across the globe beyond any geographic or social boundaries. Modern lifestyle too, by and large, stands shaped and ushered under the influences of the information technology.

Awareness, in its simplest manifestation, symbolizes a better understanding of the things around. For a commoner it pertains to a normal comprehension of 'what, why and how' of the happenings and occurrences in his socio-cultural and physical world. It, thus, adds to the general wellbeing of a citizen by keeping him, in the latest jargon, updated. Every episode and event in the surroundings casts some impacts, expectedly and unexpectedly, on individuals' life. Having an appropriate understanding of the things and the happenings in one's surroundings places one in somewhat advantageous position in tackling with the situation. It helps one strategize the best possible and the fruitful line-of-action.

Modern society in general, is a knowledge society where facts and their information form the basis for the decisions and the actions. The levels of consciousness present in a societal group determine its collective behavior, responsiveness and handling of various issues facing the society. Environmental issues are among the gravest challenges of our time. The warming planet, melting ices, rising sea levels, disappearing life-forms species after species, thinning atmosphere, degrading lands, spreading deserts, changing climatic regimes, etc. pose great threats to the spectrum of life on the planet. Directly and indirectly all this disruption and chaotic state of affairs in the natural environment has been created by the man himself and, accordingly, with him only lies the solution, if any. He has removed the trees, poisoned the land, polluted his ambiance, contaminated the waters, killed the fellow living beings, and has emptied the resource-treasuries lying under and over the ground. Every citizen of the world irrespective of his location or nation is bound to suffer on account of it. Scientists and environmentalists, world over, are concerned about the future of mankind on the earth. What they opine and stresses for is the urgency of creating awareness and thereby mobilization of the individuals, the societies and the political regimes so that something substantial can be done for the sake of our own survival. Ecologists and climatologists are busy doing strenuous research in their respective fields in order to explore the possible remedies. Various environmental agencies and organizations are active at local and global levels. Governments, world over, are concerned to make policies, frame laws, ratify acts and adopt rules and regulations to tackle the situation in this regard. But the common man, by and large, remains untouched and uninvolved in the entire process-the process which requires his pivotal participation for the implementation part. Corrective measures for each and every environmental crisis, be it local or global, are bound to be initiated at local and individual level.

Suggested Activities for the Students/Readers:

- *Make discussion on environmental issues a habit. Do talk to your friends, teachers and elders, whenever and wherever you feel suitable, about current local and global environmental problems. Tell them what you know and learn from what they say.*
- *Join groups and organisations who work in the field of environment and nature such as WWF-I or BNHS or any other such organisation in your area.*
- *Begin reading newspaper articles and periodicals such as 'Down to Earth', WWF-I newsletter, BNHS Hornbill, Sanctuary magazine, etc. that will tell you more about our environment.*
- *Do visit environmental websites and groups or pages on social networking sites such Facebook, etc.*
- *Keep watch on changes in your surroundings. Try to record the changes and find the causes behind them.*
- *Help to conserve resources by taking part in discussions on environmental issues. Organise and support Tree Talks, plantation campaigns and awareness programmes in your area.*
- *Practice and promote reusing of resources, recycling of wastes, reducing the waste generation and buying eco-friendly products.*
- *Avoid and discourage use of tobacco, spitting in open, creating noise, throwing garbage on roads and soils, etc.*
- *Take part warmly in events organised on World Environment Day, Wildlife Week, international Wetland Day, Forestry day, Earth Hour, etc.*
- *Visit a forest, a water body, a grassland, a National Park or a Wildlife Sanctuary and spend some time there. Watch and think about beautiful forms of life there.*

There are major stakeholders-ranging from industrialists to politicians-responsible for destroying environmental equilibrium for huge materialistic gains but alongside are the ordinary individuals who too play a considerable role in the destructive direction. They, knowingly or as mostly unknowingly, get involved in the environmental destruction merely for the lack of proper awareness. This is a universal observation that the populaces, more often than not, become unreceptive and defensive against any governmental efforts aiming at environmental protection. Environmental protection attempts fail or do not achieve the desired results mostly due to non cooperation by the public. Regrettably in our context even the literate class is not as aware about the actual environmental scenario as it ought to be, let alone the general masses. Politicians in our part of the world hardly have any idea about ecological crises. Despite lot of hue and cry, the level of environmental consciousness among masses is too low to enable them realize the nature and the magnitude of the environmental crises. Elites in the society talk everything at social events except our ethical responsibilities with regard to our environmental assets. Moulvis and pundits never venture to preach about saving environment. Teachers in colleges and universities do involve in organizing debates and conferences on environmental issues but rarely think beyond the showcases to protect natural environment.

To tackle with the environmental challenges requires a behavioral change in the society. It requires an awakening in the public and this awakening must assume the form of a strong movement-a movement not confined to the elites but one which is started and carried by the masses. Launch and success of such a movement relies entirely on its reception and perception by the general masses. A proper system requires to be in place to aware the masses about the alarming environmental scenario they are caught in and to educate them of their role and responsibility towards the Mother Nature. Public needs to be informed accurately and effectively so as to make individuals think and act, at the grass root level, towards the sustainability. The scientific and realistic information about various aspects of ecological crises must be diffused through the masses in convincing ways to equip them with clarity of concepts and productive ideas. The present situation where everybody, as a trendy, talks of environment and ecology but lacks the concrete information must be converted into a situation where everyone perceives the ecological threats as real ones and looks resolved and determined to do something for a better tomorrow. Introduction of a module course on environmental awareness at graduate level is a good omen but not enough in any way.

RECAPS AND PRACTICES

Walk and Talk

(Facts in brief)

- Environmental complex on the earth formed the basis of origin and evolution of life
- Air, water and soil including different forms of life contained in them are the essential components of environment of man and everything else that lives on the earth.
- It is the environmental factors after genetics that determine the characteristics of individuals, populations and communities of living organisms
- Different sciences come together to understand and study various aspects of environment and is called as Environmental science
- Environmental studies is, generally, an awareness or specifically focused course that deals current environmental issues more from a social perspective
- E. P. Odum is regarded as the most prominent scientist in the fields of ecology and environmental science. He has written a famous book on ecology-Fundamentals of Ecology.
- Man has realized about his excesses in his surroundings which has suffered a lot due to man's greed.
- Various organizations have come up to work for environmental protection and sustainable approach of economic progress.
- Some international organizations involved with various aspects of environmental protection include:
  - Earth System Governance Project (ESGP)
  - Global Environment Facility (GEF)
  - Intergovernmental Panel on Climate Change (IPCC)
  - International Union for Conservation of Nature (IUCN)
  - United Nations Environment Programme (UNEP)
  - World Nature Organization (WNO)
  - Centre for Science and Environment (CSE)
  - International Union for Conservation of Nature (IUCN)
  - Plant A Tree Today Foundation (PATT)
  - World Wide Fund for Nature (WWF)

Practice and Prepare

(Self Tests)

Choose the correct answer

1. Term 'environment' is derived from a
   a. German word b. Latin word
   c. English word d. None of the above **Ans.** d
2. In troposphere, temperature
   a. Rises with height b. Remains unchanged
   c. Declines with height d. First declines than rises with height
   Ans. c
3. Troposphere is
   a. Up to 50km at poles
   b. Up to 20km at equator and 8km at the poles
   c. Up to 8km at equator and 20km at the poles
   d. Up to 60km at equator **Ans. b**
4. Which is the innermost layer of atmosphere?
   a. Ionosphere b. Troposphere
   c. Mesosphere d. None of the above **Ans. b**
5. Temperature rises while moving upward in
   a. Troposphere b. Stratosphere
   c. Hydrosphere d. Mesosphere **Ans. a**
6. Fauna means
   a. Animals b. Plants
   c. Micro organisms d. Flowers **Ans. b**
7. 'Centre for Science and Environment' is located at
   a. Los Angelis b. Delhi
   c. New York d. Jammu **Ans. b**
8. MAB stands for
   a. Man and Biosphere b. Mechanical and biological
   c. Major association of biologists d. None of the above **Ans. a**
9. Temperature is
   a. Abiotic factor b. Biotic factor
   c. Not an Environmental factor d. None of the above **Ans. a**

10. WWF stands for
    a. World wrestling federation.
    b. Worldwide fund for nature
    c. Worldwide food.
    d. World wasteland functionary

Ans. b

11. Ionosphere is, sometimes, also called as
    a. Thermosphere
    b. Troposphere
    c. Exosphere
    d. Tropopause

Ans a

12. Ozone is
    a. Mono atomic gas
    b. Di- atomic gas
    c. Tri-atomic gas (O_3)
    d. Tri-atomic vapours

Ans. c

13. Which is the most common gas found in THE atmosphere?
    a. CO
    b. Neon
    c. Oxygen
    d. Nitrogen

Ans. d. Nitrogen (78.08%)

14. Water has maximum density at
    a. 100p C
    b. 10p C
    c. 4p C
    d. Op C

Ans. c

15. Oceans contain........% of total water on THE earth's surface
    a. 97%
    b. 70%
    c. 3%
    d. 75%

Ans. a. 97% (97.60%)

16. Which element is the most abundant one in the earth's crust
    a. Oxygen
    b. Silicon
    c. Iron
    d. Calcium

Ans .a. Oxygen (49.85%)

17. Which is the most common mineral compound on the earth?
    a. Feldspar
    b. Mica
    c. Quartz
    d. Pyroxene

Ans. a Feldspar(58.2%)

18. Disintegration of rocks and formation of soil is called
    a. Soil formation
    b. Weathering
    c. Climate
    d. Pedogenesis

Ans. b

19. Word 'environment' is derived from another word 'envirron' which is a
    a. Latin word
    b. French word
    c. Greek word
    d. English word

Ans. b

20. Term ‘ecology’ is derived from word “oikos” which means
    a. Household
    b. Economics
    c. Oxygen
    d. None of the above **Ans. a**

Chapter 2

Life and Ecosystem

To halt the decline of an ecosystem, it is necessary to think like an ecosystem

Douglas Wheeler

Objectives

In this unit, we will discuss:

- ✓ Origin and characteristics of life
- ✓ Ecosystem and Ecology
- ✓ Structure and functions of ecosystem
  - o Functional aspects of an ecosystem
  - o Material/nutrient cycling in ecosystem
  - o Ecosystem productivity
- ✓ Ecological succession
- ✓ Ecosystem-examples

CHAPTER 2 LIFE AND ECOSYSTEM

The first law of ecology is that everything is related to everything else

Barry Commoner, 1971

ABSTRACT

Life originated in water as a single celled organism and evolved, over billions of years, into a web of diverse forms. All life forms are interlinked and interdependent. The complex of life together with abiotic components of the environment forms an ecological system in which transformation of energy and materials takes place. Sun is the only source of energy to run the ecosystems on the earth. Energy, water, nitrogen and soil minerals are other essential abiotic components of an ecosystem. Energy generally enters the system through photosynthesis, a process that also captures carbon from the atmosphere. Green plants, thus, harvest solar energy and make it available to other life-forms. By feeding on plants and on one another, animals play an important role in the movement of matter and energy through the system. By breaking down dead organic matter, decomposers release carbon back to the atmosphere and facilitate nutrient cycling by converting nutrients stored in dead biomass back to a form that can be readily used by plants and other microbes

INTRODUCTION

Life is a characteristic combination of physical entities having biological processes (such as signaling and self-sustaining processes). Various forms of life exist such as plants, animals, fungi, protists, archaea, and bacteria. Human beings stand at the top in the hierarchy of life. Biology is the primary science concerned with the study of life, although many other sciences are also involved.

Imagine a cat sitting on a table in your room and staring at you, or a flower fresh and fragrant in a gamla. You know that the cat and the flower are alive where as the table and the gamla aren't. But if you examine the cat and the table or the flower and the gamla at atomic and molecular levels, you will find that the differences between them blur. Cats, tables and all other things are made of atoms and molecules which behave according to the same physical laws. There is something that differentiates living organisms from non living things though both are composed of atomic and molecular assemblages. This something is 'life'. Cell is the basic unit of life. It is composed of biochemical molecules. However an organism is taken as the first living system. Living organisms must gather energy and materials from their surroundings to build new molecules, grow in size, maintain and repair their parts and produce offsprings. Some living organisms such as bacteria and protozoan consist of a single cell(they are unicellular) whereas others such as fungi, plants and animals, consist of large number of cells(they are multicellular. A group of similar organisms (i.e belonging to the same species) in a particular area at a particular time is called Population. Number of populations (organisms of different species taken collectively) in an area are called a community. An identical or distinguishable portion of the earth containing several communities is called a biome. Entire zone on earth consisting of living organisms is known as Biosphere (discussed in unit 1). Biosphere along with its environment is called Ecosphere.

DETAILS AND DISCUSSIONS

2.1. ORIGIN AND CHARACTERISTICS OF LIFE

Owing to its unique environment, the earth is the only planet to harbor life. on the earth we can find living organisms from the poles to the equator, from the bottom of the sea to several miles in the air, from freezing waters to dry valleys Over the last 3.7 billion years or so, living organisms on the Earth have diversified and adopted to diverse environmental conditions. The diversity of life is truly amazing, but all living organisms do share certain similarities. All living organisms can replicate, and the replicator molecule is DNA. Earlier, living organisms were divided into two kingdoms: animal and vegetable, or the Animalia and the Plantae. Now the most often used scheme divides all living organisms into five kingdoms: Monera (bacteria), Protista, Fungi, Plantae, and Animalia. This coexisted with a scheme dividing life into two main divisions: the Prokaryotae (bacteria, etc.) and the eukaryotae (animals, plants, fungi, and protists). Another type of biological entities, the viruses, are not organisms in the same sense as other living organisms are. However, they are of considerable biological importance. No one knows the exact number of species present on the earth. Scientist, however, believe it to be somewhere between 10M to 80M. Only about 1.4M species have so far been enlisted and only 2.5 to 12% of the total number of spiecies on the earth are described.

Extraterrestrial life

Earth is the only known planet to have life. It is because of its unique environment which is also known as the life-support-system. Other locations within our Solar System that may host life include subsurface Mars, the atmosphere of Venus and subsurface oceans on some of the moons of the gas giant planets. Astroecology experiments with meteorites show that Martian asteroids and cometary materials are rich in inorganic elements and may be fertile soils for microbial, algal and plant life, for past and future life in our and other solar systems. Some people believe that the life originated somewhere else and then transferred to Earth in the form of spores via meteorites, comets, or cosmic dust. (source: wikipedia)

Levels of organization

The entire world around us is made up of

- **Space,**
- **Matter, and**
- **Energy**

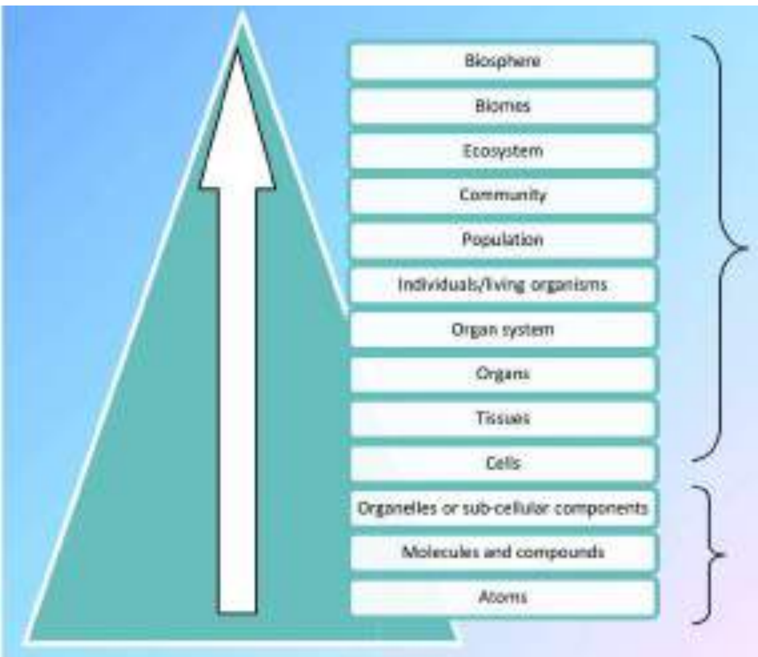


Fig. 2.1. Life on the earth: Levels of organization (Jazib, 2012)

Space is expressed in terms of area etc. and is present everywhere around. Everything around us is made up of some substances or materials called matter. This matter is expressed in terms of mass. Energy is present in the universe as an important ingredient that makes this world functional. Space, matter and energy are the subject matter of various Physical Sciences.

Atom is the lowest level of organization in the living world and non-living world while biosphere is the highest level of organization in the living world. Atoms, molecules and chemical compounds are non living but are very important for life. Life starts at the level of cells which form tissues and organs. An organism is the first living entity for ecological studies. Populations, communities, ecosystems and the entire biosphere are the study area of ecology. Each level in this hierarchy of biological organisation is unique in its structure and function and shows additional properties than those of its lower level. At every level there emerge some unique properties, also known as emergent properties, which are always more than the properties of its constituent parts taken together.

2.2. ECOSYSTEM

Life does not exist in space or isolation. It needs a substratum which provides space, necessary substances and favourable conditions for living organisms. In an area, the community of living organisms interacts with its physical environment to form a definite structural and functional system. This structural and functional unit of life in nature is called an Ecological System or simply an Ecosystem.

The term **ecology** has been derived from a Greek word 'oikos' (Oikos=household/ habitat; logos=study). The word "ecology" ("Ökologie") was coined in 1866 by the German scientist Ernst Haeckel. It relates to the scientific study of organisms or groups of organisms in their natural habitat. The science of ecology is often categorized as a branch of biosciences that studies the interactions among organisms and their environment, such as the interactions organisms have with each other and with their abiotic environment. Earlier , two other terms viz. **ethology** and **hexicology** were also used for such studies but they the newer term ecology predominated. Different ecologists have defined Ecology in different ways:

Ecology is the scientific study of the distribution and abundance of animals.

(Andrewartha,1961)

Study of interactions of form, function and factors is ecology.

(R. Mishra, 1967)

Study of structure and function of nature may be defined as ecology.

(Odum, 1971)

The Scientific study of the interactions that determine the distribution and abundance of organisms is known as ecology.

(Krebs,1985)

> Ecology is the study of the relationships between organisms and the totality of the physical and biological factors affecting them or influenced by them.
>
> **(Pianka, 1988)**

Ecology can be divided into various subdivisions such as:

On the basis of taxonomic affinities

- Plant Ecology- Study of interrelationships of plants with their environment.
- Animal Ecology- Study of interrelationships of animals with their environment

Based on habitat:

- Habitat ecology-Study of habitats and their effects upon the organisms.

Based on levels of organization:

- Autecology- ecological study of one species of organisms.
- Synecology-ecological studies of more than one species of organisms.
- Population ecology-Study of interactions between individuals of same species.
- Community ecology-Study of interactions between individuals of different species.
- Biome ecology-Study of interaction between different communities of a biome.
- Eco-system ecology-Study of interactions between the biotic and abiotic components of an eco-system.

Based on specialised fields of ecology:

- Freshwater ecology: Study of interactions among freshwater organisms.
- Marine ecology: Study of interactions among marine organisms.
- Zoogeography: Geographic distribution of animals.
- Phytogeography: Geographic distribution of plants.
- Statistical ecology-Statistical studies on population, sampling techniques and community problem.
- Estuarine ecology-Study of interactions among estuarine organisms.
- Terrestrial ecology-Study of interactions among terrestrial (land) organisms.

Now, coming back to the ecosystem.

An ecosystem is a spatial and organizational unit which is formed by the interactions of living organisms with each other and with their physical environment. Thus, the community of living organisms (plants, animals and micro-organisms) in any area taken together with their non-living environmental components (such as soil, air and water) forms an ecosystem. . A pond, grassland, garden, forest, etc are the common examples of ecosystem. The earth's living organisms interacting with their physical environment (i.e biosphere) may be considered as a giant and vast ecosystem. On the contrary a small pool of water containing certain forms of living organisms (such as plants, insects, microorganisms, etc) may also be regarded as an ecosystem.

Every ecosystem, big or small, has some common characteristics. Structure and function are the important aspects of an ecosystem. Various living organisms and their non-living environmental components form the structural aspect of an ecosystem. Sun is the only source of energy for any ecosystem. When energy flows through an ecosystem, it makes it functional. There are producers (plants), consumers (animals) and decomposers. These groups of living organisms are arranged in a definite sequence according to their food habits in an ecosystem. The relationship among these groups is expressed in food chains, food webs, ecological pyramids, etc. Various inorganic substances such as C, N, H, P, S, water, etc. are utilised by living community and are kept exchanged between different components of an ecosystem.

The term “ecosystem” was first used by a British ecologist **Arthur Tansley** in **1935**. He explained the concept of eco-system which can be summarised as:

- When both, biotic and abiotic components are considered, the basic structural and functional units of nature are ecosystems.
- There exist varying degrees of positive or negative or even neutral interactions among organisms at both interspecific and intraspecific levels (within the members of same species or between the members of different species).
- Energy is the driving force of this system. Energy flow is unidirectional and non-cyclic.
- There operate biogeochemical cycles in the ecosystem. This movement of nutrients within an ecosystem is always cyclic.
- The limiting factors of environment govern the successful growth of organisms. Under natural conditions, different kinds of populations undergo succession.

2.2.1 Types of ecosystems

Biosphere is the largest and an all encompassing ecosystem. However it is difficult to handle this huge system for ecological studies. It is for our convenience that we have divided this big ecosystem into smaller ecosystems based on our own spatial considerations. Ellenberg (1973) classified the world into a hierarchy of ecosystems. After biosphere, next lower level is mega-ecosystem such as marine ecosystems (seas, oceans, lakes, etc.), limnic ecosystems (fresh water ecosystems) semi terrestrial (ecosystems of wet soil and air), terrestrial and urban-industrial ecosystems (cropland, city, etc.). Lower to mega-ecosystems is, macro ecosystems as forest within a mega-ecosystem. Meso-ecosystems (such as a deciduous broad leaved forest), micro ecosystems and nano-ecosystems are still lower levels of ecosystem. These lower level ecosystems are spatially contained within another (higher level) ecosystem but show certain individuality of their own.

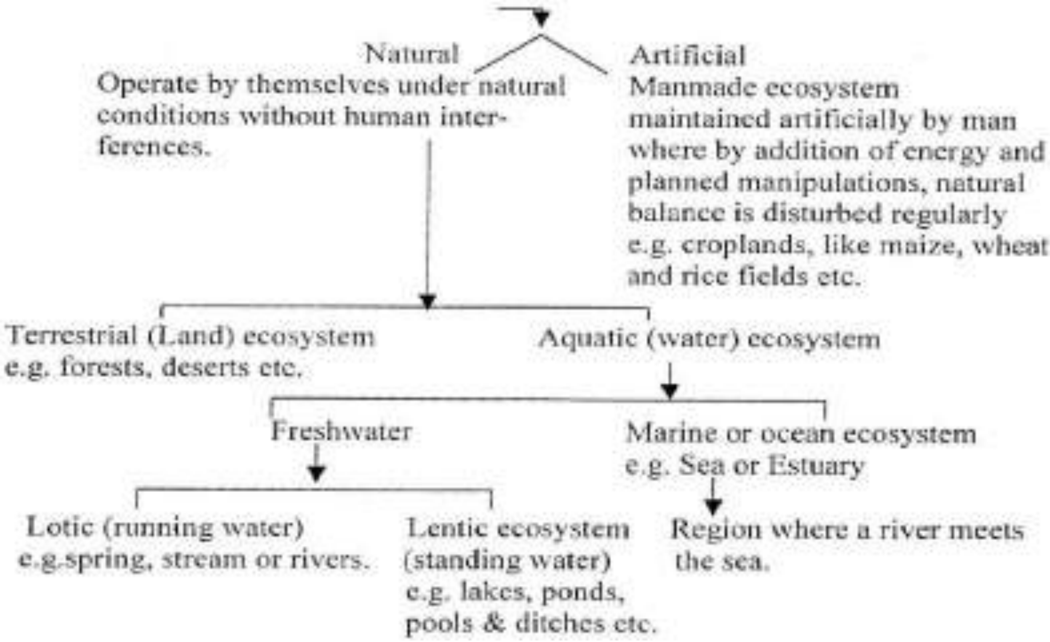


Fig. 2.2. Various types of ecosystems

In a simpler way ecosystems can broadly be categorised as under:

A. Terrestrial ecosystems: all the ecosystems on land such as a forest, a desert, grassland, a cropland, etc.

B. Aquatic ecosystems: all the ecosystems where the dominant factor is water such as a pond, a lake, a river, a spring, a lake, a sea, an ocean, etc.

C. Natural ecosystems: all the naturally occurring ecosystems where man's interruption is thought mainly to be unwarranted such as a forest, grassland, river, etc.

D. Artificial ecosystems: all the ecosystems which are created and managed by man such as a cropland, a garden, a pond, etc.

2.3. STRUCTURE AND FUNCTIONS OF ECOSYSTEM

A system is a collection of interdependent parts and/or events that make up a whole. A computer for example has its constituent parts such as CPU, monitor, input devices, etc. which together make it a system. Similarly a radio set, a mobile phone, a watch, a car or any other machine are examples of system. A computer works only when all of its constituent parts are in proper order and function appropriately. Every part has its specific functioning but all parts function together in the system, say a computer, radio or car to make it a functional system. The whole system fails to function unless there is some kind of input from the outside. System having received some input acts to produce some output. For the computer, radio or car inputs are electric power and petrol and output are a printout, sound and speed. Like any other system, ecosystem too has its structural and functional attributes. It too requires input and produces output. Energy from the sun forms the input for an ecosystem. It works and produces output called ecosystem productivity.

2.3.1. Structural aspects of an ecosystem

The physical components of an ecosystem, their inter-relationships and the resultant configuration constitute the structure of an ecosystem. This structural framework can be expressed in simple categorisation (abiotic, biotic, producers, consumers, etc) of various components or in graphical representations such as food chains, food web, ecological pyramids, etc.

As an ecosystem is not only a biological entity. It is composed of following types of general components

- **Abiotic Component**
- **Biotic Component**

A. Abiotic Components

It is the portion of an ecosystem that is non living. Rocks, soil, gases, water, temperatures, winds, other forces, etc. are abiotic component of ecosystem. It is, thus, also said to be the aggregate of environmental factors and includes:

- Climatic factors such as rainfall, humidity, temperature, light.
- Topographic factors such as altitude, slope, direction of mountain ranges etc.
- Edaphic factors such as soil composition, soil texture, soil biota etc.

These abiotic components or, otherwise, environmental factors in an ecosystem are capable of bringing marked distributional, structural and functional changes in organisms. An organism requires harmonious relationship with its immediate environment for its proper growth, reproduction, etc. The difference between the types of vegetation or consumers of a desert and a rain forest indicates the role of environmental factors on the distribution and survival of organisms in different ecosystems. These environmental factors exhibit diurnal, seasonal, annual and cyclic variations to which the organisms are subjected.

B. Biotic Components

These include the living entities in an ecosystem. They include all the microbes, animals, plants and their products. They can be categorized as:

a) **Producers or Autotrophic components**: These are the producers which convert simple inorganic substances into complex organic substances with the help of solar energy. They are of two types:

(i) Photosynthetic: They manufacture food with the help of chlorophyll in presence of sunlight so energy utilized is radiant energy. These constitute the major proportion of autotrophic components. It includes green plants, green algae and photosynthetic bacteria.

(ii) Chemosynthetic: They manufacture food with the help of chemical energy evolved during chemical reactions. They contribute to lesser extent to the production of food in an ecosystem.

In ecosystems we generally consider only green plants as producers as they manufacture their food by using energy from the sun. In the sea these include tiny algal forms to large seaweeds.

b) **Consumers or Heterotrophic components**: They consume the food produced by the producers. They are of following types.

(i) Macro consumers: These are the consumer organisms which are of larger size and feed upon the producers. Based upon their position in the food chain they can be categorized in primary, secondary and tertiary consumers.

- **Primary consumers (Herbivores)**: Eat producers such as green plants eg. Deer, goat, grasshopper, etc.
- **Secondary consumer (Smaller carnivores)**: eats herbivores (animals) eg. Snake, eagle, lizard, large fish, etc.
- **Tertiary consumers (Larger carnivores)**: Eats smaller carnivores eg. Lion, hawk, tiger, man, etc.

(ii) **Micro-consumers or Decomposers**: Decomposers are a group of organisms consisting of small animals like worms, insects, bacteria and fungi, which break down dead organic material into smaller particles and finally into simpler substances that are used by plants as nutrition. Decomposition thus is a vital function in nature, as without this, all the nutrients would be tied up in dead matter and no new life could be produced.

In simpler terms biotic component of ecosystem consists of producers (green plants), consumers (herbivore and carnivore animals) and decomposers (microorganisms).

Trophic structure

The assemblage of various living components of an ecosystem organized in an orderly manner is called its **tophic Structure**. In a trophic structure, the producers and consumers are arranged together in various levels in accordance with their inter-relationships (or simply their food-relationship) in an ecosystem. Each level in this structure is known as a trophic level. The structure and functions of an ecosystem are closely related and influence each other so intimately that they need to be studied together. The flow of energy takes place through a series of feeding relationships in a definite sequence which is known as Food Chain. Nutrients too, move along the food chains only. Usually an ecosystem may have two to six trophic levels through which energy and nutrients flow. In a more simple language all the green plants which are the primary producers of organic substances constitute one trophic level in an ecosystem. Similarly, all animals which obtain food or in other words energy by consuming green plants, such as grasshoppers, cattle, rodents, etc (ie. Primary consumers or herbivores) shall be at the same trophic level. And all those animals or predators which live on primary consumers or herbivores (i.e secondary consumers or carnivores) are said to be at a higher but same trophic level.

A. Food Chain

The sequence of eating and being eaten in an ecosystem is known as food chain. All organisms, living or dead, are potential food for some other organism and thus, there is essentially no waste in the functioning of a natural ecosystem. A caterpillar eats a plant leaf, a sparrow eats the caterpillar, a hawk eats the sparrow, and when they all die, they are all consumed by microorganisms like bacteria or fungi. Food chains usually have two to six links (or trophic levels in an ecosystem). In nature, we come across two major types of food chains as below.

(i) Grazing food chain: it starts with green plants and culminates in carnivores. Some examples are

- grass → grasshopper → frog → snake → hawk(grassland ecosystem)
- grass → rabbit → fox
- phytoplanktons → waterfleas → small fish → tuna (pond ecosystem)
- phytoplanktons → zooplanktons → fish
- lichen → riendeer → man (Arctic region)

(ii) Detritus food chain: It starts with dead organic matter which the detritivore and decomposers consume. Partially decomposed organic matter and even the decomposers are fed upon by the detritivores. Some examples are:

- Leaf litter → algae → crabs → small carnivorous fish → large fish (mangrove ecosystem)
- Dead organic matter → fungi → bacteria (forest ecosystem)
- Dead grass → termite → aardvark (grassland)

(iii) Parasitic food chain: parasites which derive nutrition from other plants andanimals also constitute a link in yet another type of food chain which may be designated as Parastic food chain. It may commence at any level in a trophic structure and may at times result in heavy losses of energy.

B. Food web

In natural ecosystems food chains rarely operate as isolated linear sequences. They are found to be interconnected and forming a complex network of several food chains together at the same time. Food web is, thus, a network of food chains where different types of organisms are connected at different trophic levels, so that there are a number of options of eating and being eaten at each trophic level. For example in grazing food chain of a grassland, in the absence of rabbit grass may be eaten by mouse. The mouse in turn may be eaten directly by hawk or by snake which is then eaten by hawk. In such a food web there may be seen as many as five linear food chains.

- grass → grasshopper → hawk
- grass → grasshopper → lizard → hawk
- grass → rabbit → hawk(or vulture or fox or even man , if present)
- grass → mouse → hawk
- grass → mouse → snake → hawk

Food webs are very important in maintaining the stability of an ecosystem in nature.

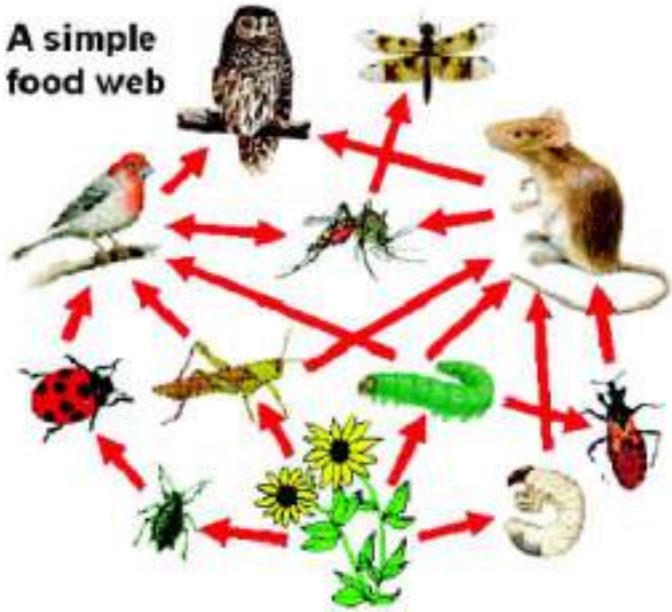


Fig. 2.3. Food web (McComas)

C. Ecological pyramids

Graphic representation of trophic structure and function of an ecosystem, starting with producers at the base and successive trophic levels forming the apex is known as an ecological pyramid. The concept of ecological pyramid was developed by Charles Elton after whose name these pyramids are also known as **Eltonian pyramids**. There are three types of ecological pyramids

(i) Pyramid of numbers. It represents the number of individuals at each trophic level. We may have upright or inverted pyramid depending upon the type of ecosystem and food chain considered. Ecosystems like a grassland or a pond show an upright pyramid of numbers. The producers in a grassland are the grasses and that in a pond are phytoplanktons(algae etc.) which are small in size but very large in number. So they (producers) form a broad base. The herbivores in grassland are insects while tertiary carnivores are hawk or other birds which are lesser and lesser in number and hence the pyramid apex becomes narrower and form an upright pyramid. Similarly in a pond ecosystem, herbivores, carnivores and top carnivores decrease in number at higher trophic levels. In a forest ecosystem, big trees are producers, which are less in number and hence form a narrow base. A large number of herbivores including birds, insects and several species of animals feed upon the trees(on leaves, fruits, flowers, bark etc) and form a much broader middle level. The secondary consumers like fox, snakes, lizards, etc. are less in number than herbivores while top carnivores (like lion, tiger, etc) are still lesser in number. So the pyramid is narrow at base, broader at middle and again narrower upwards.

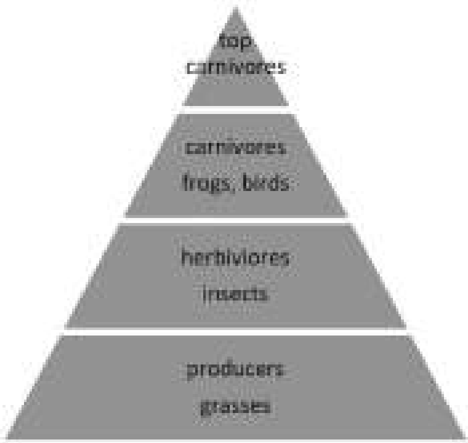


Fig. 2.4a. Upright pyramid of number as in a grassland or pond

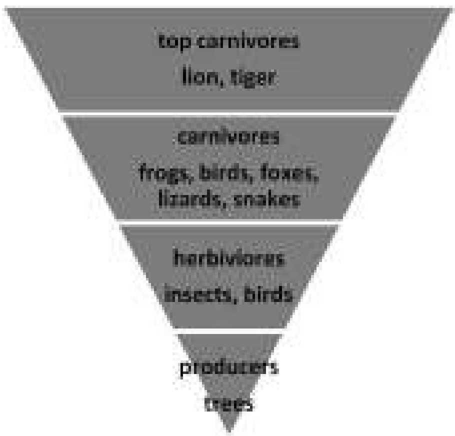


Fig. 2.4b. Pyramid of number in a forest ecosystem

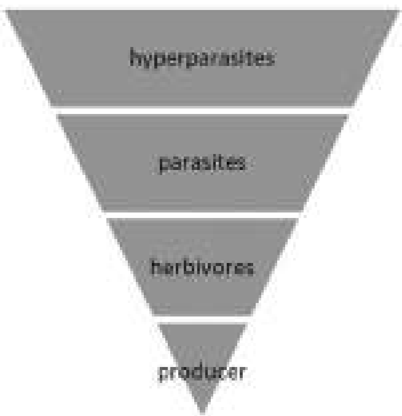


Fig. 2.4c. Inverted pyramid as shown in parasitic foodchains

Parasitic food chains show inverted pyramids. The producers like a few big trees harbor fruit eater birds which are large in number. A much higher number of lice, bugs etc grow as parasite on these birds while a still greater number of hyperparasites like bugs, fleas, microbes, etc feed upon them thus making an inverted pyramid.

(ii) Pyramid of biomass: It is based upon the total biomass at each trophic level in a food chain. The pyramid of biomass can also be upright or inverted. The pyramid of biomass in a forest ecosystem is upright in contrast to its pyramid of numbers. This is because the producers accumulate a huge biomass while the consumer's total biomass declines at higher trophic levels. The pond on the other hand shows an inverted pyramid of biomass. The total biomass of producers is much less than that of herbivores and it goes on increasing towards higher trophic levels.

(iii) Pyramid of energy

The amount of energy present at each trophic level is considered for this type of pyramid. This type of pyramid gives the best representation of the trophic relationship and it is always upright. At every successive level there is a huge loss of energy (about 90%) in the form of heat, respiration, etc. thus at each next higher level only 10% of the energy passes on. Hence there is a sharp decline in energy level of each successive trophic level as we move from producers to top carnivores.

2.3.2. Functional aspects of an ecosystem

An ecosystem works as a unit in an efficient and organized way. It receives energy from the sun and passes it on through its components and, in fact, all life depends on this flow of energy. Green plants (including phytoplanktons) alone are able to trap the solar energy in an ecosystem. They make use of this energy for their growth and maintenance. Energy gets stored as chemical bonds of large organic molecules in green plants. Heterotrophs or consumers obtain their energy requirements from this stored energy (in green plants) as food and use it for their development, growth, maintenance or other life activities. All life forms in an ecosystem are linked together by the flow of energy. Besides energy, various nutrients and water, which are also required for life processes, are exchanged by the biotic components within themselves and with their abiotic components. The flow of energy and nutrients in an ecosystem keeps it going on. This mechanism can be studied in a simplified manner as under.

Ecosystem Energetics

As stated above an ecosystem needs energy inputs from outside. Materials are used from within an ecosystem. Flow of energy in an ecosystem takes place through food chains and it is this energy flow which keeps the ecosystem going on. Most important feature of this flow is that it is unidirectional. Unlike the nutrients which move in a cyclic manner and are reused by the producers after flowing through the food chain, energy is not reused in the food chain. Flow of energy follows the laws of thermodynamics.

- First law of thermodynamics states that the energy can neither be created nor be destroyed but it can be transformed from one form to another. The solar energy captured by the green plants is converted into biochemical energy of plants and latter into that of consumers.
- Second law of thermodynamics states that energy dissipates as it is used or in other words, it gets converted from concentrated to dispersed form. As energy flows through the food chains, there occurs dissipation of energy at every trophic level. At each trophic level, about 90% of energy gets lost and only 10% of it gets transferred to the next level.

Energy Flow in Ecosystem

As mentioned above the sun is the only source of energy for the entire biosphere. Solar energy travels in electromagnetic waves form. It consists of a wide range of wavelengths and various types of radiations (infra red, visible, ultra violet, etc.) Only a specific portion of sun's electromagnetic spectrum is utilized by the producers. The amount of solar energy reaching a surface perpendicular to the sun rays at outer atmosphere is called solar constant. This is 2.00 calories per per sq cm per minute. Of this quantity about 1.00cal/sq.cm/min reaches the earth's surface. The flow of energy through various trophic levels in an ecosystem can be explained with the help of various energy flow models.

Universal energy-flow-model: As the energy enters and flows through the ecosystem there is a gradual loss of it at every level, thereby resulting in less energy available at every next trophic level. This is indicated by narrower pipes(energy flow) and smaller boxes(stored energy in biomass) in Figure below. The loss of energy is the energy not utilized (NU). This is the energy lost in locomotion, excretion, other life activities etc. or it is the energy lost in respiration(R). The rest of energy is used for production (P).

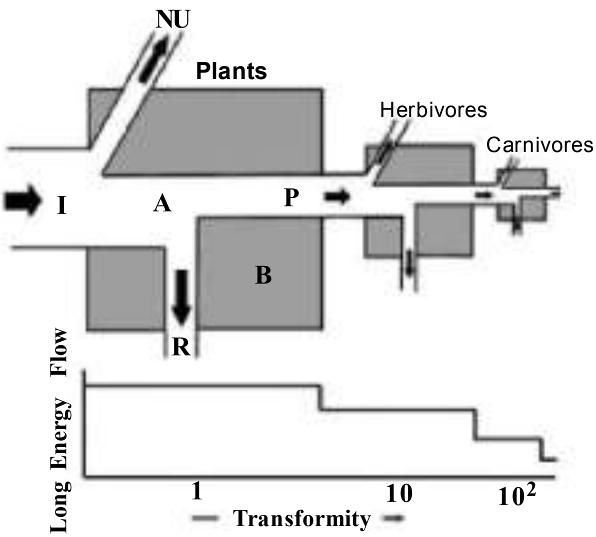
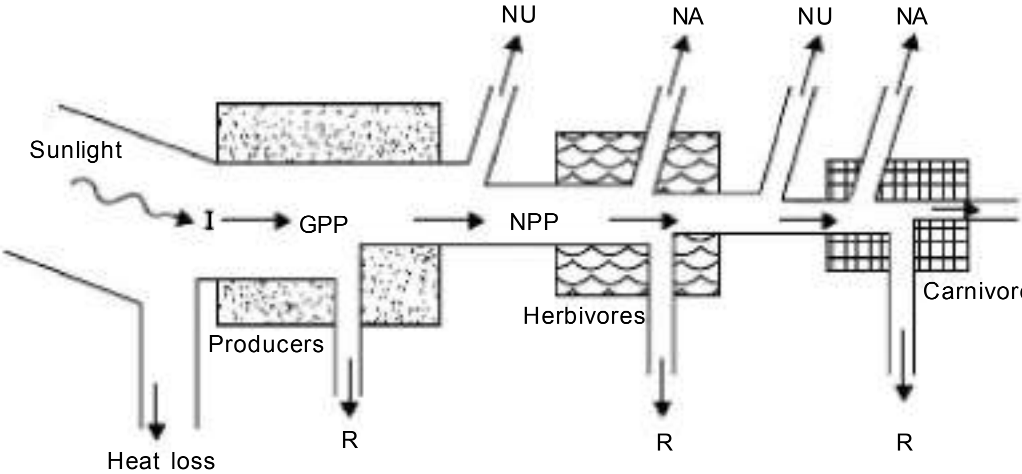


Fig. 2.5. Universal Energy Flow Model (E. P. Odum)

A. Single channel energy-flow-model: This model depicts the flow of energy in ecosystem an ecosystem through a single channel or linear sequence. Energy enters as sunlight in an ecosystem and flows from green plants or producers to herbivores and carnivores. During this energy flow, there is a gradual decline in energy level due to loss of energy at each successive trophic level in a grazing food chain.



GPP=gross primary production
NU=not utilised
NA= not assimilated R=respiratory losses
R= respiration losses

Fig. 2.6. Single Channel Energy Flow Model

B. Double channel or Y-shaped energy-flow-model: This model is more realistic as it considers both types of food chains found in natural ecosystems. In nature both grazing food chain and detritus food chains operate in the same ecosystem. In a forest ecosystem a huge quantity of biomass produced cannot be all consumed by herbivores. A large proportion of the live biomass enters into the detritus (dead) component of ecosystem in the form of litter. Hence the detritus food chain is equally important. In marine ecosystems, however, a major portion primary production is eaten by the herbivorous marine animals. Therefore, very little primary production is left to be passed on to the dead or detritus component. The Y-shaped model of energy flow shows the passage of energy through ecosystem where both grazing and detritus food chains operate together.

Material/Nutrient Cycling in Ecosystem

Besides energy flow the other important functional attribute of an ecosystem is nutrient cycling. All organisms require two types of nutrients: Macro-nutrients and Micro-nutrients (Macro-nutrients: Required in large amounts e.g. C, N, O, H, S, P, Ca, Mg etc.; Micro-nutrients: required in small amounts e.g. Fe, Mn, Cu, Zn, B, Co, Cl, Na, etc.).Nutrients like carbon, nitrogen, sulphur, oxygen, hydrogen, phosphorus, etc. move in circular paths through biotic and abiotic components and are therefore known as biogeochemical cycles. There are two types of biogeochemical cycles - (i) gaseous; and (ii) sedimentary (Gaseous-Reservoir lies in atmosphere e.g. C, N, O cycle etc.; and, Sedimentary-Reservoir lies in the earth's crust e.g. P, S, Ca, etc. Water also moves in a cycle known as hydrological cycle. The term "**biogeochemical**" indicates that in these cycling of nutrients biological, geological and chemical factors are all involved in the process. The circulation of chemical nutrients and water takes place through the biological as well as physical world. In effect, the elements are recycled, although in some cycles there may be places (called reservoirs) where the elements are accumulated or held for a long period of time (such as an ocean or lake for water). The nutrients move through the food chains and ultimately reach the detritus component (containing dead organic matter) where various microorganisms carry out the process of decomposition. Various organically bound nutrients of dead animal and plants are converted into inorganic substances by microbial decomposition and are again used up by plants and the cycles start afresh (*Kaushak and Kaushak, 2006*). Some of the important biogeochemical cycles are being briefly discussed here.

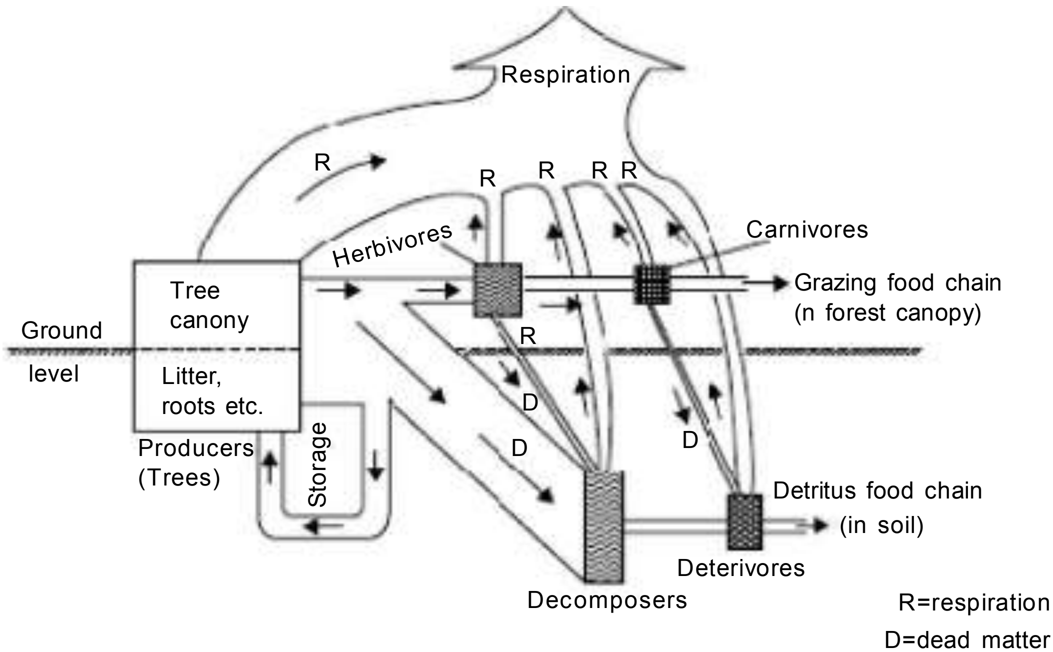


Fig.2.7. Double Channel Energy Flow Model (Kaushak and kaushak, 2006)

Nitrogen cycle

Nitrogen is present in the atmosphere as N2 in large amount (78%) and it is fixed either by the physical process of lightening or biologically by some bacteria and/or cyanobacteria (blue green algae). The nitrogen is taken up by plants and used in metabolism for biosynthesis of amino acids, proteins, vitamins etc. and passes through the food chain.

After death of the plants and animals, the organic nitrogen the organic nitrogen in dead tissues is decomposed by several groups of ammonifying and nitrifying bacteria which convert them into ammonia, nitrites and nitrates, which are again used by plants. Some bacteria convert nitrates, into molecular nitrogen or N2 which is released back into the atmosphere and the cycle goes on.

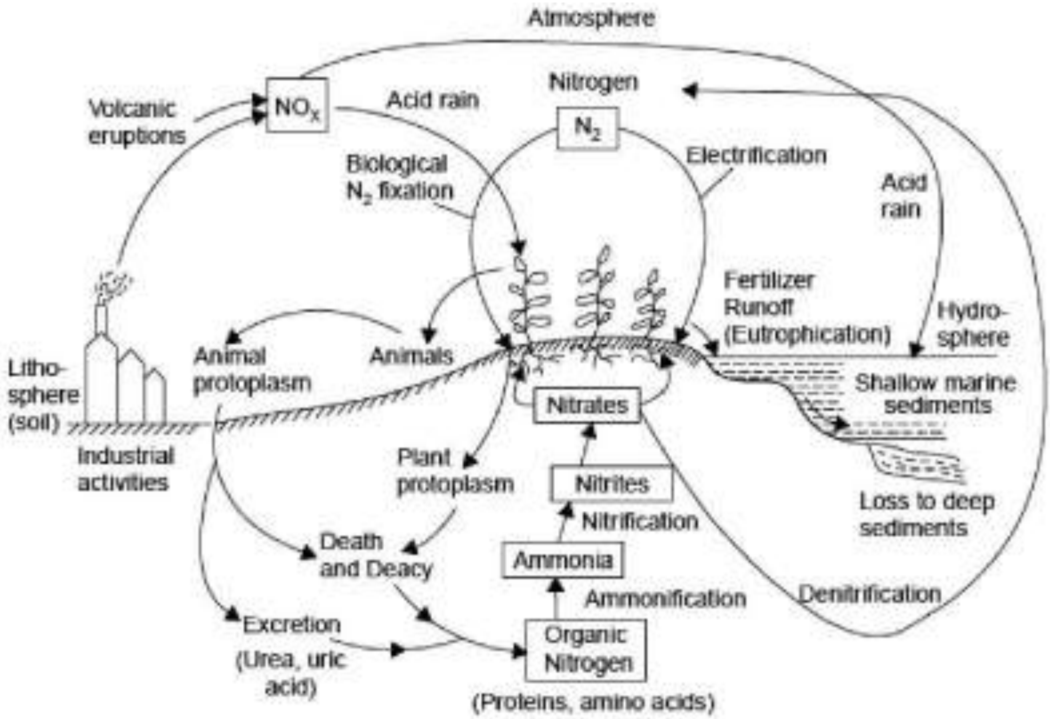


Fig. 2.8. Nitrogen cycle (Kaushak and Kaushak, 2004)

Carbon cycle

Carbon is taken up by green plants in the form of carbon dioxide as a raw material for photosynthesis. In the process a variety of carbohydrates and other organic substances are produced. So it moves through the food chains and ultimately organic carbon present in the dead matter is returned to the atmosphere as carbon dioxide by microorganisms. Respiration by all organisms produces carbon dioxide which is released in the atmosphere from where is used up by plants.

In the recent years carbon dioxide levels have increased in the atmosphere due to burning of fossil fuels etc. It has caused an imbalance in the natural cycle and the world today is facing the serious problem of global warming due to enhanced carbon dioxide emissions in the atmosphere.

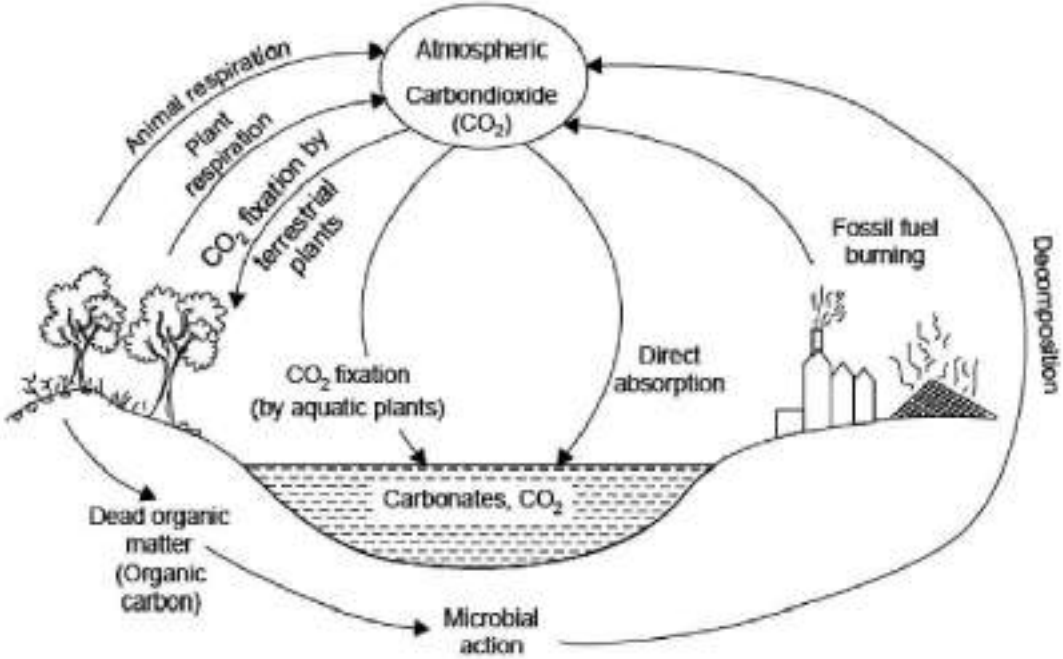


Fig. 2.9 Carbon cycle (Kaushak and Kaushak, 2004)

Phosphorus Cycle

Reservoir of phosphorus lies in the rocks, fossils etc. which is excavated by man for using it as a fertilizer. Farmers use the phosphate fertilizers indiscriminately and as a result excess phosphates are lost as run-off, which causes the problem of eutrophication of lakes leading to algal blooms. A good proportion of phosphates moving with surface runoff reaches the oceans and lost into the deep sediments. Our limited supply of phosphorus lying in the phosphate rocks of this earth are thus over-exploited by man and a large part

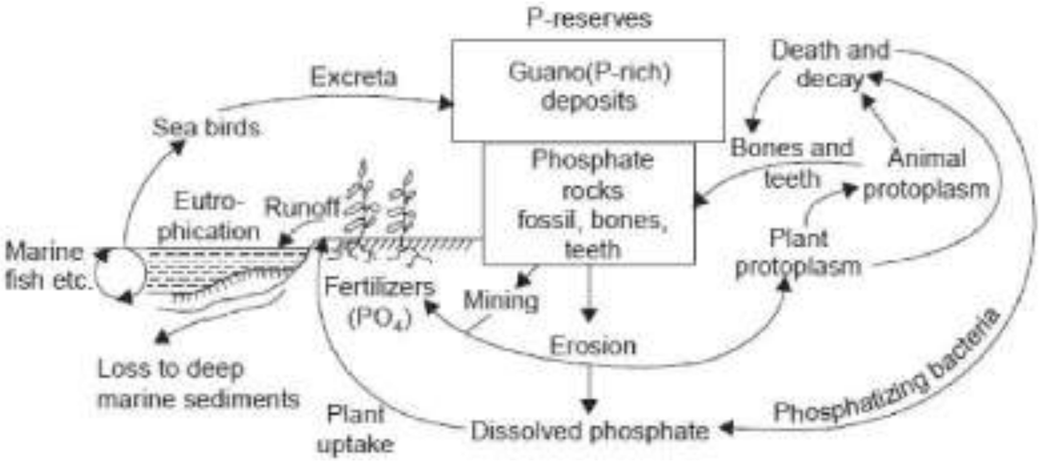


Fig. 2.10. Phosphorus cycle (Kaushak and Kaushak, 2004)

is taken out of the normal cycle due to loss into oceans. So human beings are making the phosphorous cycle acyclic. Sea birds, on the other hand, are playing an important role in phosphorus cycling. They eat sea-fishes which are phosphorus rich and the droppings or excreta of the birds return the phosphorus on the land. The Guano deposits on the coasts of Peru are very rich sources of phosphorus.

Oxygen Cycle

Oxygen is taken up by plants and animals from the air during respiration. The plants return oxygen to the atmosphere during photosynthesis. The main source of atmospheric free oxygen is photosynthesis, which produces sugars and free oxygen from carbon dioxide and water:

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

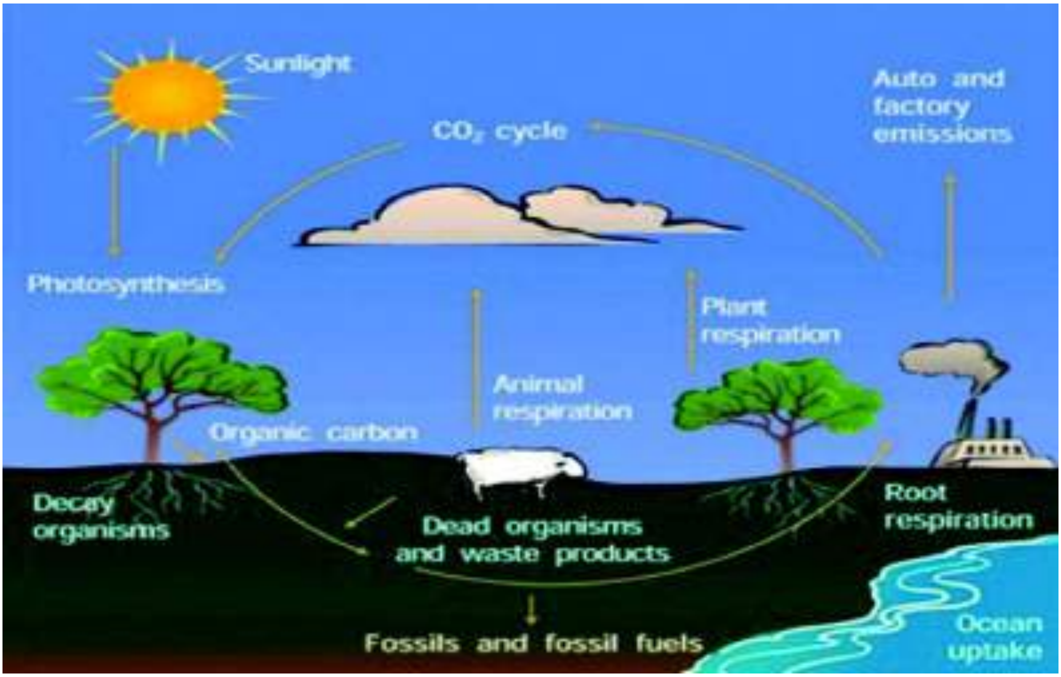


Fig. 2.11. Oxygen cycle (Sayeed, 2018)

Photosynthesizing organisms include the plant life of the land areas as well as the phytoplankton of the oceans. The tiny marine *Cyanobacterium prochlorococcus* accounts for more than half of the photosynthesis of the open ocean. An additional source of atmospheric free oxygen comes from photolysis, whereby high-energy ultraviolet radiation breaks down atmospheric water and nitrous oxide into component atoms. The free H and N atoms escape into space, leaving O_2 in the atmosphere:

$$2\ H_2O + \text{energy} \rightarrow 4\ H + O_2$$
$$2\ N_2O + \text{energy} \rightarrow 4\ N + O_2$$

The main way free oxygen is lost from the atmosphere is via respiration and decay, mechanisms in which animal life and bacteria consume oxygen and release carbon dioxide.

The lithosphere also consumes free oxygen by chemical weathering and surface reactions. An example of surface weathering chemistry is formation of iron oxides (rust):

$$4\ FeO + O_2 \rightarrow 2\ Fe_2O_34\ FeO + O_2 \rightarrow 2\ Fe_2O_3$$

Oxygen is also cycled between the biosphere and lithosphere. Marine organisms in the biosphere create calcium carbonate shell material (CaCO3) that is rich in oxygen. When the organism dies, its shell is deposited on the shallow sea floor and buried over time to create the limestone sedimentary rock of the lithosphere. Weathering processes initiated by organisms can also free oxygen from the lithosphere. Plants and animals extract nutrient minerals from rocks and release oxygen in the process.

Hydrological cycle

The mass of water on Earth remains fairly constant over time but the partitioning of the water into the major reservoirs of ice, fresh water, saline water and atmospheric water is variable depending on a wide range of climatic variables. The water moves from one reservoir to another, such as from river to ocean, or from the ocean to the atmosphere, by the physical processes of evaporation, condensation, precipitation, infiltration, runoff, and subsurface flow. In doing so, the water goes through different phases: liquid, solid (ice), and gas (vapor). The water cycle, also known as the hydrologic cycle, describes the continuous movement of water on, above and below the surface of the Earth.

The sun, which drives the water cycle, heats water in oceans and seas. Water evaporates as water vapour into the air. Ice,rain and snow can sublimate directly into water vapour. Evapotranspiration is water transpired from plants and evaporated from the soil. Rising air currents take the vapour up into the atmosphere where cooler temperatures cause it to condense into clouds. Air currents move water vapour around the globe, cloud particles collide, grow, and fall out of the upper atmospheric layers as precipitation. Some precipitation falls as snow or hail, sleet, and can accumulate as ice caps and glaciers, which can store frozen water for thousands of years. Most water falls back into the oceans or onto land as rain, where the water flows over the ground as surface runoff. A portion of runoff enters rivers in valleys in the landscape, with stream flow moving water towards the oceans. Runoff and water emerging from the ground (groundwater) may be stored as freshwater in lakes. Not all runoff flows into rivers, much of it soaks into the ground as infiltration. Some water infiltrates deep into the ground and replenishes aquifers, which can store freshwater for long periods of time. Some infiltration stays close to the land surface and can seep back into surface-water bodies (and the ocean) as groundwater discharge. Some groundwater finds openings in the land surface and comes out as freshwater springs. In river valleys and flood-plains there is often continuous water exchange between surface water and ground water in the hydrospheric zone. Over time, the water returns to the ocean, to continue the water cycle.

The water cycle involves the exchange of energy, which leads to temperature changes. For instance, when water evaporates, it takes up energy from its surroundings and cools the environment. When it condenses, it releases energy and warms the environment. These heat exchanges influence climate.

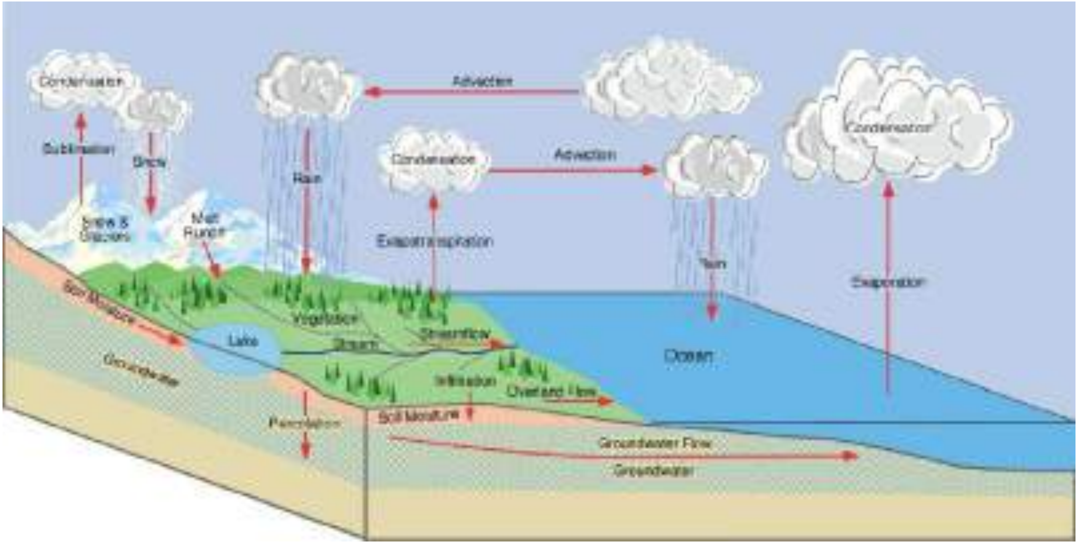


Fig. 2.12. Hydrological cycle (USGS)

The evaporative phase of the cycle purifies water which then replenishes the land with freshwater. The flow of liquid water and ice transports minerals across the globe. It is also involved in reshaping the geological features of the Earth, through processes including erosion and sedimentation. The water cycle is also essential for the maintenance of most life and ecosystems on the planet.

Biogeochemical cycles are also the links between different components of the environment such as lithosphere, hydrosphere, atmosphere and biosphere. They portray the movements of substances on the entire globe.

Together in a systematic manner these cycles are responsible for maintaining life on earth. If man, through his excessive interference, disturbs these cycles beyond the limits that nature can sustain, they will eventually break down and lead to a degraded earth on which man will not be able to survive.

2.4.1. Ecosystem Productivity

Production, in ecology, is related with the generation of biomass in an ecosystem. The productivity of an ecosystem thus refers to the rate of production i.e. the amount of organic matter, which is accumulated in any unit time. It is usually expressed in units of mass per unit surface (or volume) per unit time, for instance grams per square metre per day (g m^{-2} d^{-1}).

Productivity of autotrophs such as plants is called primary productivity, while that of heterotrophs such as animals is called secondary productivity.

Primary production

Primary production is the synthesis of new organic material from inorganic molecules such as H_2O and CO_2. It is dominated by the process of photosynthesis which uses sunlight to synthesise organic molecules such as sugars, although chemosynthesis represents a small fraction of primary production. These are the green plants, higher saprophytes as well as lower forms, the phytoplanktons and some photosynthetic bacteria. We can define Primary productivity as "the rate at which radiant energy is stored by photosynthetic and chemosynthetic activity of producers." Primary production of an ecosystem depends upon the solar radiations, availability of water and nutrients and upon the type of the plants and their chlorophyll content. Productivity of tropical forests and estuaries are the highest. This is because tropical forests have abundant rainfall, warm temperature congenial for growth, abundant sunlight and a rich diversity of species. Primary productivity is of two types.

A. **Gross primary productivity**: it is the total rate of photosynthesis including the organic matter used up in respiration. It is also called as Total assimilation. Primary productivity i estimated either in terms of chlorophyll content as Chl/g dry weight per unit area or amount of CO2 fixed /g Chl/hour.

B. **Net primary productivity** is the rate of storage of organic matter in plant tissues in excess of the respiratory utilization by plants during the measurement period. This is, thus, the rate of increases of biomass and is also known as Net Assimilation. In this way, net primary productivity refers to balance between gross photosynthesis and respiration and other plant losses as death etc.

Secondary production

Secondary production is the generation of biomass of heterotrophic (consumer) organisms in a system. This is driven by the transfer of organic material between trophic levels, and represents the quantity of new tissue created through the use of assimilated food.Organisms responsible for secondary production include animals, protists, fungi and many bacteria. Secondary productivity is thus rate of energy storage at consumers' level. Since consumers only utilize food materials (already produced) in their respiration, simply covering the food matters to different tissues by an overall process. The secondary productivity is not divided into 'gross' and 'net' amount.

Net Productivity: Net productivity refers to the rate of storage of organic matter not used by the heterotrophs (consumer) i.e. equivalent to net primary production minus consumption by the heterotrophs during the unit period. It is thus the rate of increase of biomass of the primary producers, which has been left over by the consumers.

2.4. ECOLOGICAL SUCCESSION

Succession is a gradual process in which structure of an ecosystem gets changed over time. Ecosystems are not static in nature. They are always in a state of change and dynamism. It is actually the structure of biotic community that evolves in the process. They change themselves in accordance with the prevalent environmental conditions. These changes are very orderly and predictable. It is seen that at a particular place a particular community of organisms is totally replaced by another over a period of time. Ecological succession can be defined as an orderly process of changes in the structure and function of a community in ecosystem with time mediated by modifications in environmental complex.

Succession takes place because through the processes of living, growing and reproducing, the organisms interact with and affect their environment and gradually change it. Each species is adapted to thrive and compete best against other species under a very specific set of environmental conditions. If these conditions change, then the existing species will be outcompeted by a different set of species which are better adapted to the new conditions. Change in the plant species present in an area is one of the driving forces behind changes in animal species. This is because each plant species will have associated animal species which feed on it. The presence of these herbivore species will then dictate which particular carnivores should be present. Likewise the microbial communities are also influenced by the plant and animal communities present at a particular place. So the ºengineº of succession, the cause of ecosystem change, is the impact of established species upon their own environments. Hence the process of ecological succession is mediated by the interaction between the biotic communities and their environment.

In very simple terms ecological succession is a natural process by which different groups or biological communities colonize the same area over a period of time in a sequence. The first ever living organisms that colonize a place and start the process of succession are known as pioneers. The communities which follow pioneers are known as the seres or seral communities and the final community of plants and animals that establishes itself after the process of succession is known as climax community.

2.4.1 Types of succession

A. **Primary succession**: It occurs in essentially lifeless areas—regions in which the soil is incapable of sustaining life as a result of such factors as lava flows, newly formed sand dunes, or rocks left from a retreating glacier.

B. **Secondary succession**: It occurs in areas where a community that previously existed has been removed; it is typified by smaller-scale disturbances that do not eliminate all life and nutrients from the environment.

C. **Autogenic Succession**: If the existing community itself causes its replacement by some other community it is said to be autogenic succession.

D. Allogenic succession: If the existing community is replaced by another community due to some external force it is called allogenic succession.

E. Autotrophic succession: Here the early and continued dominants are autotrophs. There is gradual increase in the organic matter content supported by energy flow.

F. Heterotrophic succession: Here early dominants are heterotrophs. There is progressive decline in energy content.

Depending upon the environment where the process of succession takes place, it is denoted with different terms such as:

a) Hydrosere: Succession takes place in water such as in ponds, lakes and stream.

b) Xerosere: Process of succession begins in xerophytic or desert like conditions.

c) Lihosere: Succession starts on rocks or rocky background.

d) Halosere: Succession takes place in saline water or soil

e) Psammosere: Succession, here, takes place in sand.

2.4.2 Causes of Succession

There are three major causes of succession:

A. Initial or initiating causes: These are climatic as well asbiotic. Climatic factors include erosion and deposits, wind, fire etc caused by lightening or volcanic activity and biotic include various activities of organisms. These causes produce bare areas or destroy the existing populations in an area.

B. **Ecesis (continuing) causes**: These are the processes as migration, ecesis, aggregation, competition reaction etc which cause successive waves of populations as a result of changes chiefly in the edaphic features of the area.

C. **Stabilizing causes**: These cause the stabilization of the community. Climate of the area is the chief cause of stabilization.

2.4.3 General Mechanism of succession

The whole process of a primary succession is completed through a number of sequential steps, which follow one another. These steps in sequence are as follows:

A. Nudation: This is the development of a bare area without any form of life due to several causes such as landslide, erosion, deposition etc. The cause of nudation may be:

i) **Topographic**: Due to soil erosion by gravity, water or wind, the existing vegetation may disappear. Other causes may be deposition of sand etc., landslide, volcanic activity and other factors.

ii) **Climatic**: Glaciers, dry period, hails and storm, frost, fire etc may also destroy the vegetation.

iii) **Biotic**: Man is responsible for destruction of forests, grasslands etc. for industry, agriculture, housing etc. Other factors are disease epidemics due to fungi, viruses etc which destroy the whole population.

B. Invasion: It is the successful establishment of a species in a bare area. The process is completed in following 3 successive stages:

i) Migration (dispersal): The seeds, spores or other propagules of the species reach the bare area. This process is known as migration, and is generally brought about by air, water etc.

ii) Ecesis (establishment): After reaching to new area, the process of successful establishment of the species starts and is known as ecesis.

iii) Aggregation: After ecesis, as a result of reproduction, the individuals of the species increase in number and they come close to each other. This process is known as aggregation.

C. Competition and Co-action: After aggregation of a large number of individuals of the species at the limited place, there develops competition mainly for space and nutrition. Individuals of a species affect each other's life in various ways and this is called co-action.

D. Reaction: This is the most important stage in succession. The mechanism of modification of the environment through the influence of living organisms on it is known as reaction. is a result of reactions, changes take place in the environment and as a result it gets modified, becoming unsuitable for existing community which sooner or later replaced by another community. The whole sequence of communities that replaces one another in the given area is called a sere and various communities constituting the sere are known as seral communities, seral stages or developmental stages.

E. Stabilization (climax): Finally, there occurs a stage whenthe final terminal community becomes more or less stabilized for a longer period of time and it can maintain itself in equilibrium with the climate of the area. This final community is not replaced and is known as climax community and the stage as climax stage.

Theories about climax

There are three schools of interpretations explaining the climax concept:

Monoclimax or Climatic Climax Theory: It was advanced by Clements (1916) and recognizes only one climax whose characteristics are determined solely by climate (climatic climax). The processes of succession and modification of environment overcome the effects of differences in topography, parent material of the soil, and other factors. The whole area would be covered with uniform plant community. Communities other than the climax are related to it, and are recognized as subclimax, postclimax and disclimax.

Polyclimax Theory: It was advanced by Tansley (1935). It proposes that the climax vegetation of a region consists of more than one vegetation climaxes controlled by soil moisture, soil nutrients, topography, slope exposure, fire, and animal activity.

Climax Pattern Theory. It was proposed by Whittaker (1953). The climax pattern theory recognizes a variety of climaxes governed by responses of species populations to biotic and abiotic conditions. According to this theory the total environment of the ecosystem determines the composition, species structure, and balance of a climax community. The environment includes the species responses to moisture, temperature, and nutrients, their biotic relationships, availability of flora and fauna to colonize the area, chance dispersal of seeds and animals, soils, climate, and disturbance such as fire and wind. The nature of climax vegetation will change as the environment changes. The climax community represents a pattern of populations that corresponds to and changes with the pattern of environment. The central and most widespread community is the climatic climax.

2.5 ECOSYSTEM-EXAMPLES

Owing to the great diversity in the physical environment of the earth there is also a great diversity in the ecosystems of the world. There are terrestrial and aquatic ecosystems ranging from lakes and oceans to forests and deserts. All ecosystems, however, exhibit similar general structural and functional framework. Some examples of the main ecosystems are briefly illustrated here.

Terrestrial ecosystems include forests, grasslands, deserts, etc.

2.5.1. Forest Ecosystem

A forest is a natural terrestrial ecosystem where the trees, shrubs, climbers and ground flora in plants and several groups of mammals, birds, reptiles and microorganisms in animals predominantly form the structure the biotic community. Each forest type forms a habitat for a specific community of animals that are adapted to live in it. The types of forests present in a particular geographic region are determined by the environmental conditions prevalent in that region. Forests on the mountains and hills differ from those along the river valleys. Similarly in the type of vegetation and the animal communities vary from forest to forest. In India, for instance, the coniferous tree specis occur in the Himalayas, mangrove trees in river deltas and the thorn trees and bushes grow in the arid regions. Likewise among animals, the snow leopard, wild sheep and goats live in the Himalayas while the leopard and tiger are found in the forests of the rest of India.

Like any other ecosystem a forest ecosystem consists structurally of two components.

a. **Abiotic component**: it consists of the physical environment of a forest including climatic and edaphic (soil) conditions. Climatic conditions such as precipitation, temperature, etc. differ from place to place and so do the forest types. Forest soil is very rich in humus or organic matter and it differs from other types of soil.

b. Biotic component: It includes various groups of plants, animals and microorganisms. Plants include the trees, shrubs, climbers, grasses, and herbs in the forest. These include species that flower (angiosperms), and non-flowering species (gymnosperms) such as ferns, bryophytes, fungi and algae. Trees are the dominant vegetation group in a forest. The animals include species of mammals, birds, reptiles, amphibians, insects and other invertebrates.

Depending upon the prevailing climatic conditions forests can be of various types:

(a) Tropical Rain Forests: They are evergreen broadleaf forests found near the equator. They are characterized by high temperature, high humidity and high rainfall, all of which favour the growth of trees. They are the richest in biodiversity. Different forms of life occupy specialized areas (niches) within different layers and spaces of the ecosystem depending upon their needs for food, sunlight, water, nutrient etc. We come across different types and layers of plants and animalsin the tropical rain forests. e.g. the emergent layer is the topmost layer of the tallest broad-leaf evergreen trees, below which lies the canopy where top branches of shorter trees form an umbrella like cover. Below this is present the understory of still smaller trees. On the tree trunks some woody climbers are found to grow which are known as Lianas.

There are some other plants like Orchids which are epiphytes i.e. they are attached to the trunks or branches of big trees and they take up water and nutrients falling from above. The orchids have special type of leaves to capture and hold the water. Some large epiphytes can hold as much as 4 litres of water, equivalent to a small bucket! Thus, these epiphytes almost act like mini-ponds suspended up in the air, in the forest crown. That is the reason why a large variety of birds, insects and animals like monkeys have made their natural homes (habitats) in these forests. The under storey trees usually receive very dim sunlight. They usually develop dark green leaves with high chlorophyll content so that they can use the diffused sunlight for photosynthesis. The shrub layer receives even less sunlight and the ground layer commonly known as forest floor receives almost no sunlight and is a dark layer. Most of the animals like bats, birds, insects etc. occupy the bright canopy layer while monkeys, toads, snakes, chameleons etc. keep on moving up and down in sunny and darker layers. Termites, fungi, mushrooms etc. grow on the ground layer. Warm temperature and high availability of moisture facilitate rapid breakdown (decomposition) of the dropped leaves, twigs etc releasing the nutrients rapidly.

The Silent Valley in Kerala is the only tropical rain forest lying in India which is the natural habitat for a wide variety of species. Being the store-house of biodiversity, the forests provide us with an array of commercial goods like timber, fuel wood, drugs, resins, gums etc.

(b) Tropical deciduous forests: They are found a little away from the equator and are characterized by a warm climate the year round. Rain occurs only during monsoon. A large part of the year remains dry and therefore different types of deciduous trees are found here, which lose their leaves during dry season.

(c) Tropical scrub forests: They are found in areas where the dry season is even longer. Here there are small deciduous trees and shrubs.

(d) Temperate rain forests: They are found in temperate areas with adequate rainfall. These are dominated by coniferous trees like pines, firs, redwoods etc. They also consist of some evergreen broad-leaf trees.

(e) Temperate deciduous forests: They are found in areas with moderate temperatures. There is a marked seasonality with long summers, cold but not too severe winter and abundant rainfall throughout the year. The major trees include broad leaf deciduous trees like oak, hickory, poplar etc.

(f) Evergreen coniferous forests (Boreal Forests): They are found just south of arctic tundra. Here winters are long, cold and dry. Sunlight is available for a few hours only. In summer the temperature is mild, sun-shines for long hours but the season is quite short. The major trees include pines, spruce, fir, cedar etc. which have tiny, needle-shaped leaves having a waxy coating so that they can withstand severe cold and drought. The soil is found to get frozen during winter when few species can survive. The leaves, also known as needles, fall on the forest floor and cover the nutrient poor soil. These soils are acidic and prevent other plants from growing. Species diversity is rather low in these forests.

Forest types in India

Forests in India can broadly be divided into two main categories viz., Coniferous forests and Broadleaved forests. They can also be classified according to the nature of their tree species – evergreen, deciduous, xerophytic or thorn trees, mangroves, etc.

They, sometimes, may also be classified according to the most abundant species of trees such as Sal, Teak, Oak, Pine, Deodar or Chinar forests.

Coniferous forests grow in the Himalayan mountain region, where the temperatures are low.

These forests have tall stately trees with needle like leaves and downward sloping branches so that the snow can slip off the branches.

Broadleaved forests have several types, such as evergreen forests, deciduous forests, thorn forests, and mangrove forests. Broadleaved forests have large leaves of various shapes.

2.5.2 Grassland ecosystem

Grassland ecosystem the grasses and shrubs form the dominant part of vegetation. It grows in areas where rainfall is usually low and the soil depth and quality is poor.

A variety of grasses, herbs, and several species of insects, birds and mammals have evolved so that they are adapted to these wide-open grass covered areas. Three types of grasslands are found to occur in different climatic regions:

(a) Tropical grasslands: They occur near the borders of tropical rain forests in regions of high average temperature and low to moderate rainfall. In Africa, these are typically known as Savannas, which have tall grasses with scattered shrubs and stunted trees. The Savannas have a wide diversity of animals including zebras, giraffes, gazelle, antelopes etc. Fires are quite common during dry season. Termite mounds are very common here. Tropical savannas have a highly efficient system of photosynthesis. Most of the carbon assimilated by them in the form of carbohydrates is in the perennating bulbs, rhizomes, runners etc. which are present underground. Deliberate burning of these grasslands can relase huge quantities of carbon dioxide, a green house gas, responsible for global warming.

(b) Temperate grasslands: They are usually found on flat, gentle sloped hills, winters are very cold but summers are hot and dry. Intense grazing and summer fires do not allow shrubs or trees to grow. In the United States and Canada these grasslands are known as prairies, in South America as Pampas, in Africa as Velds and in central Europe and Asia they are known as Steppes. Winds keep blowing and evaporation rate is very high. It also favours rapid fires in summer. The soils are quite fertile and therefore, very often these grasslands are cleared for agriculture.

(c) Polar grasslands (Arctic Tundra): They are found in arctic polar region where severe cold and strong, frigid winds along with ice and snow create too harsh a climate for trees to grow. In summers the sun-shines almost round the clock and hence several small annual plants grow in the summer. The animals include arctic wolf, weasel, arcticfox, reindeer etc. A thick layer of ice remains frozen under the soil surface throughout the year and is known as permafrost. In summer, the tundra shows the appearance of shallow lakes, bogs etc. where mosquitoes, different type of insects and migratory birds appear.

Grassland Types in India

Grasslands form a variety of ecosystems that are located in different climatic conditions ranging from near desert conditions to moist conditions.

The Himalayan pasture belt extends up to the snowline. These Himalayan pastures have a large variety of grasses and herbs. Himalayan hill slopes are covered with thousands of colourful flowering plants. There are also a large number of medicinal plants. The patches of tall elephant grass, which grows to a height of about five meters, are located in the low-lying waterlogged areas.

Himalayan wildlife requires both the forest and the grassland ecosystem as important parts of their habitat. The animals migrate up into the high altitude grasslands in summer and move down into the forest in winter when the snow covers the grassland.

The Semi-arid plains of Western India, Central India and the Deccan are covered by grassland tracts with patches of thorn forest. Several mammals such as the wolf, the blackbuck, the chinkara, and birds such as the bustards and floricans are adapted to these arid conditions.

The Scrublands of the Deccan Plateau are covered with seasonal grasses and herbs on which its fauna is dependent. It is teaming with insect life on which the insectivorous birds feed.

The grasses are the major producers of biomass in these regions. Each grassland ecosystem has a wide variety of species of grasses and herbs.

2.5.3 Desert ecosystem

A desert is an arid or semi arid area with very low annual rainfall and sparse patches of vegetation. Desert ecosystems witness very extreme climatic conditions, either too hot as in Thar desert or too cold as in Ladakh. Deserts occupy one-fifth of the Earth's land surface. These ecosystems occur in regions where evaporation exceeds precipitation (rainfall, snow etc.). The precipitation is less than 25 cm per year. Deserts have little species diversity and consist of drought resistant or drought avoiding plants. The atmosphere is very dry and hence it is a poor insulator. That is why in deserts the soil gets cooled up quickly, making the nights cool.

Deserts are of three major types, based on climatic conditions:

(a) **Tropical deserts** like Sahara and Namib in Africa and Thar desert, Rajasthan, India are the driest of all with only a few species.

(b) **Temperate deserts** like Mojave in Southern California where day time temperatures are very hot in summer but cool in winters.

(c) **Cold deserts** like the Gobi desert in China and High altitude cold desert in ladakh have cold winters and warm summers.

Desert plants and animals show most typical adaptations for conservation of water. Many desert plants are found to have reduced, scaly leaves so as to cut down loss of water due to transpiration or have succulent leaves to store water. Many a times their stems get flattened and develop chlorophyll so that they can take up the function of photosynthesis. Some plants show very deep roots to tap the groundwater. Many plants have a waxy, thick cuticle over the leaf to reduce loss of water through transpiration.

Desert animals like insects and reptiles have thick outer coverings to minimize loss of water. They usually live inside burrows where humidity is better and heat is less. Desert and semi arid regions have a number of highly specialized insects and reptiles. The rare animals include the Indian wolf, desert cat, desert fox and birds such as the Great Indian Bustard and the Florican. Some of the commoner birds include partridges, quails and sand grouse.

Desert soil is rich in nutrients but deficient in water. Due to low species diversity, shortage of water and slow growth rate, the desert plant communities, if faced with a severe stress take a long time to recover.

The **Thar Desert** in Rajasthan is most typical desert landscape in india. This has sand dunes. There are also areas covered with sparse grasses and a few shrubs, which grow if it rains.

In most areas of the Thar the rainfall is scanty and sporadic. In an area it may rain only once every few years.

Aquatic ecosystems

Ecosystems where water is the dominant environmental factor in controlling abiotic characteristics and the floral and faunal makeup are known as the aquatic ecosystems. They include oceans, seas, estuaries, rivers, lakes, ponds, etc.

Abiotic characteristics

Some of the important abiotic environmental factors of aquatic ecosystems include substrate type, water depth, nutrient levels, temperature, salinity, and flow. It is often difficult to determine the relative importance of these factors without rather large experiments. The amount of dissolved oxygen in a water body is frequently the key substance in determining the extent and kinds of organic life in the water body. Fish need dissolved oxygen to survive, although their tolerance to low oxygen varies among species; in extreme cases of low oxygen some fish even resort to air gulping. Plants often have to produce aerenchyma, while the shape and size of leaves may also be altered. Conversely, oxygen is fatal to many kinds of anaerobic bacteria.

Nutrient levels are important in controlling the abundance of many species of algae. The relative abundance of nitrogen and phosphorus can in effect determine which species of algae come to dominate. Algae are a very important source of food for aquatic life, but at the same time, if they become over-abundant, they can cause declines in fish when they decay.

The salinity of the water body is also a determining factor in the kinds of species found in the water body. Organisms in marine ecosystems tolerate salinity, while many freshwater organisms are intolerant of salt. The degree of salinity in an estuary or delta is an important control upon the type of wetland (fresh, intermediate, or brackish), and the associated animal species. Dams built upstream may reduce spring flooding, and reduce sediment accretion, and may therefore lead to saltwater intrusion in coastal wetlands.

Biotic characteristics

The biotic characteristics are mainly determined by the organisms that occur. For example, wetland plants may produce dense canopies that cover large areas of sediment—or snails or geese may graze the vegetation leaving large mud flats. Aquatic environments have relatively low oxygen levels, forcing adaptation by the organisms found there. For example, many wetland plants must produce aerenchyma to carry oxygen to roots. Other biotic characteristics are more subtle and difficult to measure, such as the relative importance of competition, mutualism or predation. There are a growing number of cases where predation by coastal herbivores including snails, geese and mammals appears to be a dominant biotic factor.

Autotrophic organisms

Autotrophic organisms are producers that generate organic compounds from inorganic material. Algae use solar energy to generate biomass from carbon dioxide and are possibly the most important autotrophic organisms in aquatic environments. in the shallow waters the biomass contribution from rooted and floating vascular plants is greater. These two sources combine to produce the extraordinary production of estuaries and wetlands, as this autotrophic biomass is converted into fish, birds, amphibians and other aquatic species. Chemosynthetic bacteria are found in benthic marine ecosystems. These organisms are able to feed on hydrogen sulfide in water that comes from volcanic vents. Great concentrations of animals that feed on these bacteria are found around volcanic vents.

Heterotrophic organisms

Heterotrophic organisms consume autotrophic organisms and use the organic compounds in their bodies as energy sources and as raw materials to create their own biomass. Euryhaline organisms are salt tolerant and can survive in marine ecosystems, while stenohaline or salt intolerant species can only live in freshwater environments.

The two main types of aquatic ecosystems are marine ecosystems and freshwater ecosystems. These major types can further be divided into many categories depending upon various environmental factors.

2.5.4 Marine Ecosystem

Marine ecosystems cover approximately 71% of the Earth's surface and contain approximately 97% of the planet's water. They generate 32% of the world's net primary production. They are distinguished from freshwater ecosystems due to the presence of dissolved compounds, especially salts in the water in high concentrations. Approximately 85% of the dissolved materials in seawater are sodium and chlorine.thoiugh the salinity varies among different marine ecosystems, seawater has an average salinity of 35 parts per thousand (ppt) of water. Various classes of organisms found in marine ecosystems include brown algae, dinoflagellates, corals, cephalopods, echinoderms, and sharks. Fishes caught in marine ecosystems are the biggest source of commercial foods obtained from wild populations

Marine ecosystems can be divided into many zones depending upon water depth and shoreline features. The oceanic zone is the vast open part of the ocean where animals such as whales, sharks, and tuna live. The benthic zone consists of substrates below water where many invertebrates live. The intertidal zone is the area between high and low tides; in this figure it is termed the littoral zone. Other near-shore (neritic) zones can include estuaries, salt marshes, coral reefs, lagoons and mangrove swamps. In the deep water, hydrothermal vents may occur where chemosynthetic sulfur bacteria form the base of the food web.

Oceans are the major sinks of carbon dioxide and play an important role in regulating many biogeochemical cycles and hydrological cycle, thereby regulating the earth's climate.

The oceans have two major life zones:

Coastal zone: this is relatively warm, nutrient rich shallow water. Due to high nutrients and ample sunlight this is the zone of high primary productivity.

Open sea: It is the deeper part of the ocean, away from the continental shelf (The submerged part of the continent). It is vertically divided into three regions:

(i) **Euphotic zone** which receives abundant light and shows high photosynthetic activity.

(ii) **Bathyal zone** receives dim light and is usually geologically active.

(iii) **Abyssal zone** is the dark zone, 2000 to 5000 metres deep. The abyssal zone has no primary source of energy i.e. solar energy. It is the world's largest ecological unit but it is an incomplete ecosystem.

Environmental problems concerning marine ecosystems include unsustainable exploitation of marine resources (for example overfishing of certain species), marine pollution, climate change, and building on coastal areas.

2.5.5 Freshwater Ecosystem

Freshwater ecosystems cover 0.80% of the Earth's surface and consist 0.009% of its total water. They generate nearly 3% of its net primary production. There are three basic types of freshwater ecosystems:

Lentic: Standing water, including pools, ponds, and lakes.

Lotic: Moving water, for example streams and rivers.

Wetlands: Areas where the soil is saturated or inundated for at least part of the time.

Lentic Water Ecosystems

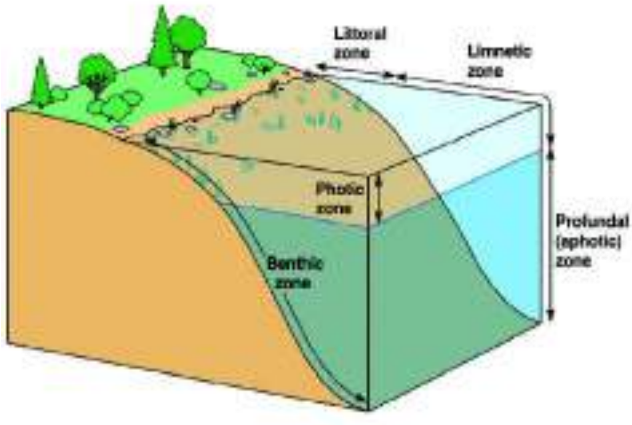


Fig. 2.14. The three primary zones of a lake (actforlibraries.org)

Lakes

Lake ecosystems can be divided into zones. The first, the littoral zone, is the shallow zone near the shore where rooted wetland plants occur. The offshore is divided into two further zones, an open water zone and a deep water zone. In the open water zone (or photic zone) sunlight supports photosynthetic algae, and the species that feed upon them. In the deep water zone(aphotic), sunlight is not available and the food web is based on detritus entering from the littoral and photic zones. Some systems use other names. The off shore areas may be called the pelagic zone, and the aphotic zone may be called the profundal zone. Towards inland from the littoral zone one can also frequently identify a riparian zone which has plants still affected by the presence of the lake—this can include effects from windfalls, spring flooding, and winter ice damage. The production of the lake as a whole is the result of production from plants growing in the littoral zone, combined with production from plankton growing in the open water. Lakes have several types of organisms:

(a) **Planktons** that float on the surface of waters e.g. phytoplanktons like algae and zooplanktons like rotifers.

(b) **Nektons** that swim e.g. fishes.

(c) **Neustons** that rest or swim on the surface.

(d) **Benthos** that are attached to bottom sediments e.g. snails.

(e) **Periphytons** that are attached or clinging to other plants or any other surface e.g. crustaceans.

Stratification: this is an important feature of temperate region lakes which show vertical zonation of its water based on temperature differences. During summer, the top waters become warmer than the bottom waters. Therefore, only the warm top layer circulates without mixing with the colder layers below. Different layers exhibit different physical, chemical and biological characteristics. Following zones are generally described in lakes which show stratification or zonation.

Epilimnion : Warm, lighter, circulating surface layer

Hypolimnion : Cold, viscous, non-circulating bottom layer.

Thermocline: In between the two -warmer and colder- layers lies the region of sharp drop in temperature which is known as thermocline.

Types of Lakes: Some important types of lakes are:

1. **On the basis of nutrient status**
   - **(a) Oligotrophic lakes** which have low nutrient concentrations.
   - **(b) Eutrophic lakes** which are overnourished by nutrients like nitrogen and phosphorus, usually as a result of agricultural run-off or municipal sewage discharge. They are covered with algal blooms. e.g. Dal Lake.
   - **(c) Dystrophic lakes** that have low pH, high humic acid content and brown waters e.g. bog lakes.

2. **On the basis of origin**
   - (d) **Volcanic lakes** that receive water from magma after volcanic eruptions e.g. many lakes in Japan. They have highly restricted biota.
   - **(e) Artificial lakes** or impoundments that are created due to construction of dams e.g. Govind sagar lake at Bhakra-Nangal, Bagliar lake near Ramban.

3. **On the basis of salt content**
   - **(f) Fresh water lakes** such as Wular lake in Kashmir
   - **(g) Saltwater lakes** eg Pangong lake in Leh
   - **(h) Meromictic lakes** that are rich in salts and are permanently stratified e.g. lake Nevada.
   - **(i) Desert salt lakes** that occur in arid regions and have developed high salt concentrations as a result of high evaporation. e.g. Sambhar lake in Rajasthan.

Others

- **(j) Endemic lakes** that are very ancient, deep and have endemic fauna which are restricted only to that lake e.g. the Lake Baikal in Russia; the deepest lake, which is now suffering a threat due to industrial pollution.

Ponds

Ponds are small bodies of freshwater with shallow and still water, marsh, and aquatic plants. They can be further divided into four zones: vegetation zone, open water, bottom mud and surface film. The size and depth of ponds often varies greatly with the time of year; many ponds are produced by spring flooding from rivers. Food webs are based both on free-floating algae and upon aquatic plants. There is usually a diverse array of aquatic life, with a few examples including algae, snails, fish, beetles, water bugs, frogs, turtles, otters and muskrats. Top predators may include large fish, herons, or alligators. Since fish are a major predator upon amphibian larvae, ponds that dry up each year, thereby killing resident fish, provide important refugia for amphibian breeding. Ponds that dry up completely each year are often known as vernal pools. Some ponds are produced by animal activity, including alligator holes and beaver ponds, and these add important diversity to landscapes.

Lotic Water Ecosystems

River ecosystem

The major zones in river ecosystems are determined by the river bed's gradient or by the velocity of the current. Faster moving turbulent water typically contains greater concentrations of dissolved oxygen, which supports greater biodiversity than the slow moving water of pools. These distinctions form the basis for the division of rivers into upland and lowland rivers. The food base of streams within riparian forests is mostly derived from the trees, but wider streams and those that lack a canopy derive the majority of their food base from algae. Environmental threats to rivers include loss of water, dams, chemical pollution and introduced species.

2.5.6 Wetland Ecosystems

Wetlands are dominated by vascular plants that have adapted to saturated soil. There are four main types of wetlands: swamp, marsh, fen and bog (both fens and bogs are types of mire). Wetlands are the most productive natural ecosystems in the world because of the proximity of water and soil. Hence they support large numbers of plant and animal species. Due to their productivity, wetlands are often converted into dry land with dykes and drains and used for agricultural purposes.

2.5.7 Estuarine ecosystem

Though a type aquatic ecosystem, an estuary is a transitional zone between marine and fresh water ecosystems and hence exhibits some unique characteristics in addition to those common with marine or fresh waters. Estuaries are places where rivers meet the sea and may be defined as areas where salt water is measurably diluted with fresh water. On average, estuaries are biologically more productive than either the adjacent river or the sea because they have a special kind of water circulation that traps plant nutrients and stimulates primary production. Fresh water, being lighter than salt water, tends to form a distinct layer that floats at the surface of the estuary. At the boundary between fresh and salt water, there is a certain amount of mixing caused by the flow of fresh water over salt and by the ebb and flow of tides. Additional mixing may be caused from time to time by strong winds and by internal waves that are propagated along the interface between fresh and salt water. Three types of estuary are recognized according to the degree of mixing: salt wedge estuaries, partially mixed estuaries and vertically homogeneous estuaries.

A salt wedge estuary has minimal mixing and the salt water forms a wedge, thickest at the seaward end, tapering to a very thin layer at the landward limit.

Organic and inorganic particles carried by rivers tend to flocculate (aggregate into a mass) and sediment out when they encounter salt water. When the organic matter decomposes, it adds still more nutrients to the estuary. The inorganic matter settles on the bottom and provides enriched sediment for flowering plants adapted to salt water. Between the tide marks, mangrove forests flourish in tropical conditions, while salt marshes form in temperate and subarctic conditions. Below low tide, sea grasses form dense beds on muddy substrates.

In a partially mixed estuary, the vigorous rise and fall of the tide generates strong turbulence and causes partial mixing between the fresh water above and the salt water below.

In a vertically homogeneous estuary the river flow is weak and the tidal flow is strong. Consequently, all stratification is broken down and salinity is almost the same from top to bottom at any given place. The salinity is lowest where the river enters the estuary and highest near the sea.

The high level of plant production in estuaries supports a correspondingly high level of production of invertebrate animals and fish. Estuaries often contain beds of shellfish such as mussels and oysters and large populations of shrimps and crabs. Fish such as plaice and flounders are common. Other species use the estuaries as nursery grounds. Organisms in early stages of development enter the salt wedge at the seaward end and are carried up the estuary by the bottom currents. Juveniles find abundant food as well as protection from predators in the mangrove forests, salt marshes, or sea-grass beds that line the estuary. Later, they may migrate to the open ocean to continue their growth and development. Other species pass through the estuaries in the course of their migrations. For example, salmon migrate from the sea to the rivers to spawn, while the young fish later migrate back to the sea. Eels migrate in the opposite direction, breeding in the sea but returning to fresh water as juveniles.

2.6. ECOSYSTEM SERVICES

Ecosystem services refer to the benefits mankind obtains from natural ecosystems present on the earth. There is a multitude of ways in which humans get benefitted from ecosystems. These benefits are collectively known as ecosystem services. Ecosystem services are classified into four categories viz. provisioning services, supporting services, regulating services and cultural services.

Provisioning services

It refers the material products obtained from ecosystems such as:

- Food including seafood, crops, wild foods, and spices
- Raw materials including lumber, skins, fuel wood, organic matter, fodder, and fertilizer.
- Genetic resources including crop improvement genes, and health care
- Water resources
- Minerals resources
- Medicinal resources including pharmaceuticals, chemical models, and test and assay organisms
- Energy resources including hydropower, biomass fuels, etc.

Supporting Services

It refers to the benefits which we get due to supportive role of ecosystems that are necessary for the production of all other ecosystem services. These include services such as nutrient recycling, primary production and soil formation.

Regulating services

It refers to those benefits which are there due to the regulation of ecosystem processes such as:

- Carbon sequestration and climate regulation
- Waste decomposition and detoxification
- Purification of water and air
- Pest and disease control

Cultural services

It refers to the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences. Cultural services include:

- Spiritual and historical (including use of nature for religious or heritage value or natural)
- Recreational experiences (including ecotourism, outdoor sports, and recreation)
- Science and education (including use of natural systems for school excursions, and scientific discovery)

RECAPS AND PRACTICES

Walk and Talk

(Facts in brief)

- Our solar system and the earth is believed to have came into existence about four and a half billion years ago. Life started on the earth about three and a half billion years ago on the earth in a reducing environment devoid of free Oxygen.
- Bacteria and some blue green algal forms were the primitive living organisms which appeared first on the planet. The remains of the earliest forms of life have been preserved in rocks known as Srtomatolites.
- Life evolved from simpler forms to present day's highly complex forms. **Speciation** is the process of origin of new species from the existing ones.
- There is immense variety of life on the earth.
- **Hexicology** and **ethology** were some other terms used prior to ecology for the similar studies.
- Green plants trap solar energy and pass it through other forms of life viz. consumers and decomposers in an ecosystem.
- Flow of energy is always **unidirectional** in ecosystems whereas flow of materials is **cyclic**.
- Efficiency of production tends to be higher at higher trophic levels. Amount of energy, however, being transferred from lower to higher trophic levels decreases successively. Out of1500 kcal of solar energy, 15kcal appears at primary producers' level, 1.5kcal at primary consumers level and only 0.3kcal is fixed at secondary consumers (carnivores) level. Production efficiency, however, rises from 1% to 10% to 20% at higher levels respectively.
- Energy quality improves where as its quantity declines with each higher level of trophic structure in an ecosystem. The energy quality is 100 times better at secondary consumers' (carnivores) level than that at primary consumers' (herbivores) level. So fats and carbohydrates are better than cellulose (grasses) and cellulose is better than the solar energy (sunlight) harvested by the primary producers.
- Ecological efficiency is the ratio of net productivity at one trophic level to net productivity at the trophic level below it.
- Net primary productivity =Grass primary productivity–plant respiration.
- Tropical rain forest ecosystem is the richest ecosystem from biodiversity as well as Net primary productivity point of views
- Different materials move in the ecosystem from one environmental component to another and from one trophic level to other. They move in a cyclic way which is

known as **biogeochemical cycle**. They include all major essential elements such as C, H, O, N, P, K, Ca, Mg, S and water. Water (H2O) is the most important compound and its movement through various ecosystem components is called **hydrological cycle**.

- The primary constituents of living matter i.e. carbon, hydrogen, nitrogen and oxygen move through **gaseous biogeochemical cycles.**
- Weathering plays primary role in **sedimentary geochemical cycles**
- When materials are in the forms and places easily accessible to life process for living organisms it is known as **active pools** of those materials
- When materials are not easily available to living organism for direct uses to life process that is known to be **storage pools** of those materials.
- Forest ecosystem are the most important among all the terrestrial ecosystem
- Temperature and precipitation are the two dominant a biotic factors of environment ,that determine the nature ,composition and extent of a particular community or ecosystem type.
- Arctic and alpine (or tundra) forest ecosystem extends from permanently frozen ice caps of northern pole to 45p N latitude. life is most difficult in this region.
- Temperate coniferous forest is also known as **taiga** biome or boreal coniferous forest and are found in south of the tundra biome between 45p Nto 57p N latitude in the northern hemisphere. this kind of forest is found in north America, Europe and northern Asia'
- Deciduous forests are found in moderate climatic condition with 75---200cm/year rainfall and 10--25p C average annual temperature.
- Tropical rain forests occur in a broad belt on either side of the equator.
- More energy is available at various levels in shorter food chains.
- Lindsman described the 80-90% energy losses at each level in a food chain.
- Aquatic ecosystems show great degree of variation in their physicochemical properties and biotic communities.
- Estuaries are the transition zone between fresh water and marine water ecosystems.
- Different groups of organisms live in aquatic ecosystems. They include planktons (zoo-and phytoplanktons) which float, nektons which swim, neustons which rest or swim on surface and benthos which live at bottom. Seaweeds form forests or kelpbeds in the seas where brown algae, green algae and red algae are also important forms of producers.
- Ecological succession is an orderly sequence of communities in an area over a period of time.
- Odium (1971) preferred to call ecological succession as ecosystem development.

- Succession results or starts due to modifications in physical environment of a community. it ends in stabilization of community with its physical environment.
- Ecological equivalents are organisms living in different regions but occupying same ecological niches or roles.
- Mivast described the term 'Hexicology' as the study of relations bet organisms and environment.
- IGS Hillaire, a French Zoologist, proposed term ethology for ecology.
- Decomposers are also called as reducers.

Practise and Prepare

(Self Tests)

(Multiple choice objective type questions)

1. Succulents is the plants group associated with which ecosystem type

   a. Forest   b. River
   c. Desert   d. Estuary

   Ans. c. Desert

2. Mangrove forests are associated with

   a. Desert   b. Estuary
   c. River   d. Ocean

   Ans. b. Estuary

3. Zone of ocean which is completely dark is called

   a. Abyssal zone   b. Photic zone
   c. Aphotic zone   d. Coastal region

   Ans. a. Abyssal zone (although in very little amounts but light can penetrate in Aphotic zone)

4. Sahara, Kalahari and Thar are the examples of

   a. Desert ecosystem   b. Marine ecosystem
   c. Forest ecosystem   d. None of the above

   Ans. a. Desert ecosystem

5. Gharana in Jammu and Hokarsar in Kashmir are

   a. Wetlands   b. Lakes
   c. Rivers   d. Forests

   Ans. a. Wetlands

6. In Parasitic Food Chain in a forest ecosystem (Oak forest), pyramid of numbers will be
   a. Upright b. Spindle shaped
   c. Straight d. Inverted **Ans. d. Inverted**
7. Detritivores are...........in a Detritus Food Chain
   a. Primary producers b. Primary consumers
   c. Secondary consumers d. None of the above
   Ans. b. Primary consumers
8. In India, Tropical Rain Forests are found in
   a. The Himalayas b. Western Ghats
   c. Assam d. Gujarat
   Ans. b. Western Ghats
9. Oceans.....
   a. Are the main sinks of CO_2 b. Play role in water cycle
   c. Neither (a) nor (b) d. Both (a) and (b)
   Ans. d. Both (a) and (b)
10. Only ....% of energy at a trophic level is transferred to the next trophic level in a food chain
    a. 10% b. 20%
    c. 25% d. 80-90%
    Ans. a. 10% (10%in herbivores and 20% in carnivores
11. Srtatification or layering of plants is found in
    a. Temperate forests b. Tropical rain forest
    c. Coniferous forests d. Mangrove forest
    Ans. b. Tropical rain forests
12. 'Pamas' are.....
    a. Grassland b. Desert
    c. Forest d. Lake
    Ans. a. Grassland (in South America).
13. Prairies of Canada are
    a. Forests b. Zoo
    c. Botanical garden d. Grasslands
    Ans. d. Grasslands

14. Average salinity of marine water is

a. 3.5%	b. 15%
c. 1%	d. 23%

Ans. a. 3.5%

15. Which among the following is a transitional zone

a. Littoral ecosystem	b. Pelagic ecosystem
c. Eustrine ecosystem	d. Benthic ecosystem

Ans. c. Esturine ecosystem

16. Standing water bodies are known as

a. Lentic	b. Lotic
c. Stagnant	d. None of the above

Ans. a. Lentic

17. Thermocline is associated with

a. Ponds	b. Oceans
c. Lakes	d. Deserts

Ans. c. Lakes

18. Which among the fallowing is an artificial ecosystem

a. Pond	b. Dam
c. Garden	d. All of the above

Ans. d. All of the above

19. In an ecosystem (Food Chain) energy flow is

a. Multidirectional	b. Cyclic
c. Unidirectional	d. Stagnant

Ans. c. Unidirectional

20. Energy is maximum at

a. Lowest trophic level	b. Highest trophic level
c. In the middle	d. None of the above

Ans. a. Lowest trophic level

21. Raw material in photosynthesis are

a. CO, and H, O	b. CO and H, O
c. O, and CO,	d. O, and C† HÅ , O†

Ans. a. CO, and H, O

22. Who gave the idia of 'ecological pyramids'

a. E. P Odum	b. P.D Sharma
c. Charles Elton	d. Hillaaria

Ans. c. Charles Elton

23. The term 'ecology' was given by
    a. A. G Tansley b. E. P Odum
    c. Ernest Haekel d. Sundarla Bahuguna

Ans. c. Ernest Haekel in 1969

24. A 'pond' is
    a. Artificial ecosystem b. Aquatic ecosystem
    c. None of the above d. Both (a) and (b)

Ans. d. Both (a) and (b)

25. Process of 'succession' on a rock is known as
    a. Psammosere b. Lithosere
    c. Halosere d. Hydrosere

Ans. b. Lithosere

26. Pyramid of energy is always
    a. Upright b. Inverted
    c. Both d. None of these

Ans. a. Upright

27. Life originated under water in a
    a. Oxidised environment b. Reducing environment
    c. Cold environment d. Lightening

Ans. b. Reducig environment

28. Basic unit of life is
    a. DNA b. RNA
    c. Cell d. Organism

Ans. c. Cell

29. Tissues are
    a. Non living b. Living
    c. Both (a) and(b) d. Neither (a) nor (b)

Ans. b. Living

30. Decomposers are also called
    a. Macroorganisms b. Microorganisms
    c. Tertiary consumers d. Digesters

Ans. b. Microorganisms

31. UN Conference on Environment and Development held in
    a. 1976 b. 1992
    c. 2010 d. 1 972

Ans. b. 1992

32. Earth receives.......of solar energy

a. 153 x 10x cal/m²/yrb. 100 x 10¹p cal/m²/yr

c. 15.3x10x cal/m²/yrd. 100000 cal/m²/yr

Ans. c. 15.3x10x /m² /yr

33. Animals feeding on vegetation as well as herbivores are called

a. Carnivores
b. Herbivores
c. Omnivores
d. Scavengers

Ans. c. Omnivores

34. Zoo planktons are

a. Plants
b. Animals
c. Gardens
d. None of above

Ans. b. Animals (of water bodies).

Chapter 3

Natural Resources

A nation that destroys its soils, destroys itself

Franklin Roosevelt

OBJECTIVES

We will discuss in this unit about:

- ✓ Natural resources: definition, concept and types
- ✓ Land resources
- ✓ Forest resources
- ✓ Water resources
- ✓ Food resources
- ✓ Energy resources

CHAPTER 3 NATURAL RESOURCES

The world has enough for everyone's need, but not enough for everyone's greed

M K Gandhi

ABSTRACT

Life on the earth depends upon a large number of things and services which are provided by nature and are, thus, known as Natural Resources. Water, air, soil, minerals, coal, forests, crops and wild life are all examples of natural resources. Natural resources vary in their nature, origin, availability, exhaustibility, extent, etc. Some natural resources, like air, solar energy, etc. are inexhaustible and thus can be used unlimitedly while as others exhaustible resources get consumed on being used and require judicious utilization. Renewable resources have the capability to renew themselves if used within certain limits. All natural resources, however, demand a proper and heady use. Reckless and injudicious utilization of natural resources is bound to usher us to an era full of all sorts of crises. It not only leads to the acute shortage of resources but may also result in generation of unmanageable wastes and contamination of our environment which is a storehouse of all the resources. There must be sustainable use of natural resources in order to safeguard our own persistent survival

INTRODUCTION

Any material which is naturally available and can be used or transformed to be used in any way by man for his well being is called a *Natural Resource*. Thus a **natural resource** is anything that we can use and which comes from nature. Air, water, sun, wood, oil, iron, and coal etc are all examples of natural resources. Natural resources, thus, must:

- Be naturally occurring on the earth.
- Useful to man in any way that is either directly in its original form or indirectly after certain modification.
- Accessible to man. If something very useful to man is known to occur somewhere but is out of human reach or we do not have appropriate tools and technology to extract or use it, it is not a natural resource for us.
- Modifiable or convertible to more useful products. It means we should have appropriate technology to make use of a natural resource.

Refined oil and hydro-electric energy are not natural resources because people make them.

The earth is seemingly an inexhaustible storehouse of innumerable natural resources. Although there are vast treasures of different resources on the earth, they are not unlimited or inexhaustible. Some resources are renewable while others are not. Man has been exploiting major groups of resources including land, fossil fuels, forests, wildlife, etc. Which have now been depleted to an irreparable extent. We need to switch over to alternative and non conventional resources in order to avoid problems associated with scarcity of resources.

DETAILS AND DISCUSSION

3.1. CLASSIFICATION OF NATURAL RESOURCES

There are numerous natural resources required and utilized by man in his day to day life. There are various basis of classifying natural resources into various groups. These bases include

- On the basis of **origin**
  - o Biotic such as forest, coal, food, etc
  - o Abiotic such as water, air, land, minerals, etc
- On the basis of **nature**
  - o Organic such as coal, oil, etc
  - o Inorganic such as coal, mica, gold, etc

- On the basis of **renewability**
  - o Renewable such as forest
  - o Non-renewable such as coal
- On the basis of **exhaustibility**
  - o Exhaustible such silver, gold, forest, oil, coal, etc
  - o Inexhaustible such as wind, solar energy, etc
- On the basis of **tradition/convention**
  - o Conventional such as oil, coal, etc.
  - o Non-conventional such as wind, tidal energy, solar energy, etc.

We often hear there are two kinds of natural resources: Renewable resources and Non-renewable resources.

- A **renewable resource** grows again and comes back again after we use it. For example, soil, sunlight, water and wood are renewable resources.
- A **non-renewable resource** is a resource that does not grow and come back, or a resource that would take a very long time to come back. For example, coal is a non-renewable resource. When we use coal, there is less coal afterward. One day, there will be no more of it to make goods. The non-renewable resource can be used directly (for example, burning oil to cook), or we can find a renewable resource to use (for example, using wind energy to make electricity).

Most natural resources are limited. This means they will eventually run out. A perpetual resource has a never-ending supply. Some examples of perpetual resources include solar energy, tidal energy, and wind energy. It is very important to protect and conserve our natural resources and use them in a judicious manner so that we do not exhaust them. It does not mean that we should stop using most of the natural resources. Rather, we should use the resources in such a way that we always save enough of them for our future generations. In the coming sections we ‘ll discuss some important natural resources such as forest resources, water resources, food resources, energy resources and land resources in detail

3.2 LAND RESOURCES

Land in general refers to any piece or entire of the terrestrial earth but as a natural resource it means that component of the earth which is of direct economic use for the human population living on it.

In fact land is one of the most important natural resources upon which we depend for our food, fibre and fuel wood, the basic amenities of life. But this resource is not infinite. There are limited land resources available for direct human use. It is the top soil or the uppermost portion of the earth crust that actually forms useful land resource. Land is classified as a renewable natural resource because it is continuously regenerated by natural process though at a very slow rate. But, when rate of erosion is faster than rate of renewal, the soil becomes a non-renewable resource. It is said that about 200-1000 years are needed for the formation of one inch of soil. Following are some important factors which affect or decide the value of land as a significant natural resource:

- Soil and terrain conditions
- Freshwater conditions
- Climatic conditions, and
- Biotic(vegetation and animal life) conditions

Land is very basic requirement of man for various types of life-related activities. He needs land for building homes, cultivating food, maintaining pastures for domestic animals, developing industries to provide goods, and supporting the industry by creating towns and cities. As a valuable resource land is, thus, used for:

- building houses, constructing roads and railways, installing industries and developing towns and cities on it
- cultivating food and fodder for humans and their livestock
- production of raw materials for industries
- raising forests and other industrial woodlands
- damping of waste generated during domestic and industrial processes

In addition to the above, we have to conserve wilderness area in forests, grasslands, wetlands, mountains, coasts, etc. to protect our vitally valuable biodiversity. This use of land is equally important.

It demands a rational use of land resources and it can be achieved through careful planning.

Land use involves the management and modification of natural environment or wilderness into built environment such as settlements and semi-natural habitats such as arable fields, pastures, and managed woods. **Land use planning** refers to policy of using a portion of land strictly for the purpose it is suitable. Different types of land are classified into various categories. Each category is assigned a suitable type of use and it should be utilised for the purpose fixed for it.

3.2.1. Global Land Use Patterns

Though the earth is a vast planet with huge surface area but 71% of it is under oceans. The Earth's total land area is 148,939,063.133 km². Out of this terrestrial surface very limited land area is effectively useful or accessible for man. A large proportion of it is either inaccessible or unfit for any cultivation or residential uses. About 15.46% of the land occurs in the cold tundra zone, which is not easily amenable to normal agriculture.

Land which is capable of being ploughed and used to grow crops is called arable land. Major categories of land include:

- o Urban or Built-up Land
- o Agricultural Land
- o Rangeland
- o Forest Land
- o Wetland
- o Barren Land
- o Degraded Land
- o Tundra
- o Perennial snow or ice

According to Buringh (1989) 11 to 12 % of the land surface is generally suitable for food and fiber production, 24 % is used for grazing, forests occupy about 31 % and the remaining 33 % has too many constraints for most uses.

Land is being put to varied types of uses worldwide. Earlier when human population was limited major portions of land were under forests and other natural cover. But with increase in human population and advancement in the technology, more and more land had been brought under various types modifications. Now more land is required to be used for agricultural purposes to meet the growing needs of food production. With his economic developmental activities gaining momentum, man put land to various other uses including establishment of industrial areas, mining, transportation, urbanisation, etc. As a result:

- Agricultural lands are expanding
- More and more land has been brought under industrial or urban setup
- Forest lands, grasslands and wetlands has been cleared of their natural cover
- Large portions of land are rendered degraded due to overexploitation
- Soil is dumped with various kinds of wastes and toxic materials

3.2.2. Land Degradation

Land degradation means reduction in the quality or value of land. When land is put to extensive use or over exploitation its quality degrades. Sometimes land is put to uses which are not suitable for that piece of land. It also degrades the land. Farmland is under serious threat due to more and more intense utilisation. Every year, between 5 to 7 million hectares of land worldwide is added to the existing degraded farmland. Some factors responsible for degradation of land include:

- Dumping of harmful wastes on land
- Over irrigation of farmland that leads to salinisation

- Pollution of land due to use of fertilizers and pesticides
- Unsuitable land use
- Soil erosion and landslides
- Wrong agricultural practices
- Deforestation

3.2.3. Soil Erosion

Soil erosion is the most common form of land degradation. It is the removal of outer layer of soil. It is defined as the movement of soil components, especially surface-litter and top soil from one place to another. Besides causing pollution in water bodies, soil erosion badly affects soil fertility. It is the top layer of soil that contains most nutrients and if most fertile. When this layer gets eroded it results in the loss of fertility. Almost one third of the world's cropland is affected by soil erosion.

Soil erosion is a natural process but it gets accelerated due various human activities. Deforestation, mining, overgrazing, cultivation, etc enhances the rate of soil erosion.

Causes of soil erosion

Various human activities like mining, deforestation, farming, overgrazing, etc are the major causes responsible for soil erosion. Due to these processes the top soil is disturbed or rendered devoid of vegetation cover. So the land is directly exposed to the action of various physical forces facilitating erosion. **Overgrazing** is responsible for **35%** of the world's soil erosion while **30%** of the serious soil erosion has been caused by **deforestation**. **Unsustainable methods of farming** cause **28%** of soil erosion.

Mechanism of soil erosion

There are two main agents which cause soil erosion. These are water and wind. Water erodes soil by washing its particles along with its flow. Wind also detaches and removes the soil particles and causes their movement from one place to another.

Soil erosion caused by **water** is of following types:

- **Sheet erosion**: when there is uniform removal of a thin layer of soil from a large surface area, it is called sheet erosion. This is usually due to run-off water.
- **Rill erosion**: When there is rainfall and rapidly running water produces finger-shaped grooves or rills over the area, it is called rill erosion.
- **Gully erosion**: It is a more prominent type of soil erosion. When the rainfall is very heavy, deeper cavities or gullies are formed on the ground.
- **Slip erosion**: This occurs due to heavy rainfall on slopes of hills and mountains.

- **Stream bank erosion**: During the rainy season, when fast running streams take a turn in some other direction, they cut the soil and make caves in the banks.

Soil erosion caused by **wind** is of following three types:

- **Saltation**: This occurs under the influence of direct pressure of stormy wind and the soil particles of 1-1.5 mm diameter move up in vertical direction.
- **Suspension**: Here soil particles of small size suspended in the air are kicked up and taken away to distant places.
- **Surface creep**: Here larger particles (5-10 mm diameter) creep over the soil surface along with wind.

3.2.4. Desertification

The process of expansion of deserts or desert like conditions on the earth is called desertification. It is the conversion of productive land to unproductive arid region. It results in reduction of agricultural productivity of land. Desertification is characterised by loss of vegetation cover. There are various natural causes of desertification such as climate but generally it is induced or enhanced but anthropogenic activities. Some of the human causes of desertification are:

- Deforestation
- Abusive agricultural practices
- Overgrazing
- Overexploitation of underground water resources
- Mining and quarrying

During last 50 years, human activities have been responsible for desertification of land area equal to the size of Brazil. The UNEP estimates suggest that if we don't make sincere efforts to stop it, then very soon 63% of rangelands, 60% of rain-fed croplands and 30% of irrigated croplands will suffer from desertification on a worldwide scale.

3.2.5. Wasteland Reclamation

Wastelands are lands which are unproductive and unfit for cultivation, grazing and other economic uses due to rough terrain and eroded soils. The wastelands include salt-affected lands, sandy areas, gullied areas, undulating uplands, barren hill-ridge etc. Snow covered areas, glacial areas and areas rendered barren after Jhum cultivation are also included in wastelands.

There may be natural as well as manmade causes responsible for wasteland formation. Anthropogenic activities leading to wasteland formation are deforestation, overgrazing, mining and intensive or faulty agricultural practices.

Classification of Wastelands

The wastelands are broadly classified into two categories.

1. **Barren and uncultivable wastelands:** These lands cannot be brought under cultivation or any other economic use at feasible costs. Such lands include sandy deserts, gully land, stony or leached land, lands on hilly slopes, rocky exposures etc.
2. **Cultivable wastelands:** These lands have not been cultivated for long times due to one reason or the other. They can be reclaimed through conservational methods for cultivation, grazing or Agroforestry.

It is reported that every year about 3 million hectares of cropland are ruined by various kinds of erosion. About 4 million hectares are converted into deserts and 8 million hectares are taken away for non-agricultural purposes such as plots for houses, roads, factories and reservoirs. The deforestation leads to soil erosion and the eroded soils exhibit droughty tendency. The loss of fertility followed by erosion also leads to the transformation of marginal forest lands into wastelands.

The official estimates of wasteland in India shows figure at 63.85 million ha which is more than 20% of country's geographic land. Maximum wasteland areas in our country lie in Rajasthan. In Jammu and Kashmir more than 72000 ha of land is wasteland.

As land resources are very limited, conservation of soil, protecting the existing cultivable lands and reclaiming the already degraded wastelands figure predominantly among the priority tasks of planning for the future. The reclamation and development of wastelands has four major ecological objectives:

- To improve the physical structure and quality of the soil
- To improve the availability and quality of water
- To prevent the movement of soil
- To conserve the biological resources of the soil

Wasteland Reclamation Practices

Reclamation and development of wasteland demands a full-fledged strategy and long term planning. For this purpose there is a central Wasteland Development Board which has undertaken this task. There are certain measures which can be adopted to improve the quality of wastelands. These different types of measures can be undertaken according to the types of the wastelands.

Afforestation: Plantation on wastelands can improve their quality. suitable fast growing plant species should be selected for various degraded lands.

Salt Removal: For reclamation of the salt affected soil, it is necessary to remove the salts from the root-zone. This is usually achieved by leaching i.e. by applying excess amount of water to push down the salts.

Drainage: In water logged areas improving the drainage improves the quality of land.

Irrigation: in areas where soil has degraded due to non availability of water artificial irrigation can solve the problem to a greater extent.

Application of fertilizers: Application of farm yard manure or nitrogen fertilizers has been found to improve saline soils. Green manure has also been reported to improve salt-affected soils.

Watershed development: in this practice entire area is managed and conserved in a systematic manner. It also helps in improving the quality of soil in the area.

3.3. FOREST RESOURCES

A forest is a large area on land dominantly covered by trees or other woody vegetation.

Forests are one of the most important natural resources on the earth. They not only produce innumerable material goods but also provide numerous environmental services which are essential for life on this planet.

Forests are the dominant terrestrial ecosystems. They account for 75% of gross productivity of the biosphere. According to the United Nations Food and Agriculture Organization forests cover about 30% of world's land area.

Forests can be classified in different ways. They can broadly be classified as:

Boreal forests: These are forests in subarctic region and are generally evergreen and coniferous.

Temperate zone forests: They include both broadleaved deciduous forests and evergreen coniferous forests.

Tropical and subtropical forests: They include tropical and subtropical moist, dry and coniferous forests.

3.3.1. Forests in India

India is a large and diverse country. Its land area includes regions with some of the world's highest rainfall to very dry deserts, coast line to alpine regions, river deltas to tropical islands. The variety and distribution of forest vegetation is large as there are about 600 species of hardwoods. There is about 27% area under forest cover in India as per World Bank report.

India is one of the 17 mega bio-diverse regions of the world. Indian forests types include tropical evergreens, tropical deciduous, swamps, mangroves, sub-tropical, montane, scrub, sub-alpine and alpine forests. These forests support a variety of ecosystems with diverse flora and fauna. A 2010 study by the Food and Agriculture Organisation ranks

India amongst the 10 countries with the largest forest area coverage in the world (the other nine being Russian Federation, Brazil, Canada, United States of America, China, Democratic Republic of the Congo, Australia, Indonesia and Sudan). India is also one of the top 10 countries with the largest primary forest coverage in the world, according to this study.

Madhya Pradesh has largest forest cover of 7.64 million hectares in India. Arunachal Pradesh has 6.9 million hectares of forest area which is 79% of its geographic area which highest percentagewise in Indian states.

Owing to varied soil and climatic conditions, there are different forest regions in India as under:

I. **The Western Himalayan region:** The region extends from Kashmir to Kumaon. Conifers and broad leaved species are found in these forests. On higher elevations blue pine, deodar, spruce and silver fir occur.

II. **The Eastern Himalayan region:** This region comprises of Darjeeling, Kureseong and the adjacent tract. This temperate zone has forests of oaks, laurels, rhodendrons, maples, alder and birch.

III. **The Assam region:** This region comprises the Brahmaputra and the Surma valleys. The region has evergreen forests, occasional thick clumps of bamboos and tall grasses.

IV. **The Ganga plain region:** This region covers the area from the Aravali hill ranges to Bengal and Orissa. Widely different types of forests are found in small areas in this region.

V. **The Deccan region:** This region has various kinds of forests ranging from scrub jungles to mixed coconut forests.

VI. **The Malabar region:** This region is rich in forest vegetation. It produces important commercial crops, such as coconut, pepper, coffee and tea besides, rubber, cashew nut and eucalyptus trees.

VII. **The Andaman region:** This region is rich in evergreen, semi-evergreen, mangrove and beach forests.

3.3.2. Forest Wealth of Jammu and Kashmir

The state of Jammu and Kashmir is covered by lofty mountains, which receive heavy rainfall and snow. Dense forests are found everywhere particularly in outer and inner Himalayan ranges. High mountains of Ladakh and Kargil receive a very little rainfall; therefore, these are devoid of forest cover. However vast grass lands and abundant medicinal and aromatic plants grow there.

1) **Sub-Tropical Dry Deciduous Forests:** These forests are generally found in the lower reaches of Shiwaliks in Jammu region. The common tree species are *Acacia*

catachu, Dalbergia sissoo, Acacia modesta, Albizzia spp, Salmlia malabarica, Eucalyptus Spp, Dendrocalamus strictus.

2) **Sub-Tropical Pine Forests:** These forests are situated in upper Shiwalik and outer Himalayas. The common species found here are *Pinus roxburghii, Albizzia spp, Dalbergia sissoo, Olea cuspidata* and other broad leaved aasociates.
3) **Himalayan Moist Temperate Forests:** This type is found in Chenab Valley. The common tree species are *Cedrus deodara, Pinus wallichiana, Picea smithiana, Pinus gerardiana, Abies pindrow (low level), Juglans regia, Acer spp, Populus ciliata, Prunus padus, Aesculus indicia, Fraxinus floribunda, Quercus spp.* etc.
4) **Himalayan Dry Temperate Forests:** This type include the main forests of Kashmir valley with the common tree species as *Cedrus deodara, Pinus wallichiana, Picea smithiana, Abies pindrow, Juglans regia, Acer spp., Prunus spp., Aesculus indicia, and the typical under wood of Parrotia jacquamentiana* etc.
5) **Alpine Forest:** These forests are situated above the main temperate zone. Common spp. found in this zone are *High level Fir and Kail, Juinpers, Quercus spp, Populus ciliata, Betual spp, Salix spp. Rhododendron,* and a variety of wild flowers and grasses.
6) **Forest in cold arid zone:** Leh and Kargil Districts fall in this zone where natural forests are meager. *Juniperous spp.* exists sporadically. Plantations of *Poplar* and *Salix* developed by the Forest Department over a period of time need irrigation. *Robinia* has been introduced in the recent past. The natural shurbs include *Hypophea and Myrcaria.* Among herbs *Artimisia* is abundantly found, besides other species of medicinal importance.

3.3.3 Uses of Forests

Some of the major uses of forest resources are summarised as below.

A. **Commercial uses:** Forests provide a large number of commercial goods such as timber, firewood, pulpwood, food items, gum, resins, non-edible oils, rubber, fibbers, lac, bamboo canes, fodder, medicine, drugs and many more items. Half of the timber cut each year is used as fuel for heating and cooking. One third of the wood harvest is used for building materials as lumber, plywood and hardwood, particle board and chipboard. One sixth of the wood harvest is converted into pulp and used for paper industry. Many forest lands are used for mining, agriculture, grazing, and recreation and for development of dams.
B. **Ecological uses:** It is not possible to express ecological value of a tree in monetary terms. Some approximations have been made, however, to underline the importance of trees in our lives. The ecological services provided by our forests may be summed up as follows:

Table 3.1 District wise Forest cover in J&K (Source: JK Forest Deptt)

Region	District	Geographical Area(Sq. Km.)	Population	Density per Sq,Km	Forest Area (Sq. Km)	% Age of geographic area
a) Kashmir	**1. Srinagar**	**2228**	**12,02,447**	**540**	**380**	**17.06**
	2. Budgam	1371	6,29,309	459	477	34.79
	3.Anantnag	3984	11,72,434	294	2068	51.91
	4.Pulwama	1398	7,52,607	467	810	57.94
	5.Baramulla	4588	11,69,780	255	2690	58.63
	6.Kupwara	2379	6,50,393	273	1703	71.58
	Sub-total: -	**15948**	**54,76,970**		**8128**	**50.97**
b) Jammu	1. Doda	11691	6,91,929	59	5555	47.52
	2. Udhampur	4550	7,43,509	163	2343	51.49
	3. Kathua	2651	5,50,084	207	991	37.38
	4. Poonch	1674	3,72,613	223	951	56.81
	5. Rajouri	2630	4,83284	184	1267	48.17
	6. Jammu	3097	15,88,772	513	959	30.97
	Sub-total	26293	44,30,191	-	12066	45.89
c) Ladakh	1. Leh	45110	1,17,232	3	29	0.06
	2. Kargil	14036	1,19,307	8	7	0.05
	Sub-total	59146	2,36,539		36	0.06
J&K State	**Total**	**101387**	**1,01,43,700**		**20230**	**19.95**

i. **Wildlife Habitat**: Forests are the homes of millions of wild animals and plants. About 7 million species are found in the tropical forests alone.

ii. **Production of Oxygen**: Forests are rightly called as earth's lungs as the trees produce oxygen (by photosynthesis) which is so vital for life on the earth.

iii. **Combating global warming**: The main greenhouse gas carbon dioxide (CO2) is absorbed by the forests as a raw material for photosynthesis. Thus forest canopy acts as a sink for CO2 thereby reducing the problem of global warming caused by greenhouse gases.

iv. **Regulation of hydrological cycle**: Forested watersheds act like giant sponges, absorbing the rainfall, slowing down the runoff and slowly releasing the water for recharge of springs. About 50-80 %of the moisture in the air above tropical forests comes from their transpiration which helps in bringing rains.

v. **Soil Conservation**: Forests bind the soil particles tightly in their roots and prevent soil erosion.

vi. **Pollution moderators**: Forests can absorb many toxic gases and can help in keeping the air pure. They have also been reported to absorb noise and thus help in preventing air and noise pollution.

3.3.4. Overexploitation of Forests

Humans have always depended heavily on forests for food, medicine, shelter, wood and fuel. With growing civilization and increasing population the demands for raw materials like timber, pulp, minerals, fuel wood etc. has rose up resulting in large scale logging, mining, road-building and clearing of forests. Excessive use of fuel wood and charcoal, expansion of urban, agricultural and industrial areas and overgrazing have together led to over- exploitation of our forests resources. This has resulted in large scale degradation of forest cover also known as Deforestation. Deforestation occurs for many reasons: trees are cut down to be used or sold as fuel (sometimes in the form of charcoal) or timber, while cleared land is used as pasture for livestock, plantations of commodities and settlements. The removal of trees without sufficient reforestation has resulted in damage to habitat, biodiversity loss and aridity. It has adverse impacts on biosequestration of atmospheric carbon dioxide.

3.3.5. Causes of Deforestation

According to the United Nations Framework Convention on Climate Change (UNFCCC) secretariat, the overwhelming direct cause of deforestation is agriculture. Subsistence farming is responsible for 48% of deforestation; commercial agriculture is responsible for 32% of deforestation; logging is responsible for 14% of deforestation and fuel wood removals make up 5% of deforestation. Some of the major causes of deforestation are:

- **Commercial logging**: it includes removal of forest wood for commercial purposes. Large tracts of forest have been cleared for supplying constructional and timber wood to the local and world market.
- **Agriculture**: Forest lands have been converted to agricultural farms in order to meet the food requirements of increasing population. Shifting cultivation is a very serious problem causing large scale deforestation in the North eastern states in India. There are an estimated 300 million people living as shifting cultivators who practice slash and burn agriculture and are supposed to clear more than 5 lakh ha of forests for shifting cultivation annually.
- **Fuel requirements**: Increasing demands for fuel wood by the growing population in India has become another cause of deforestation in our country.
- **Raw materials for industrial use**: Wood for making boxes, furniture, railway-sleepers, plywood, match-boxes, pulp for paper industry etc. have exerted tremendous pressure on forests. Plywood is in great demand for packing tea for Tea industry of Assam while fir tree wood is exploited greatly for packing apples in J&K. This has put increased pressure on already decreasing forest cover.
- **Urbanization and industrialization**: with increasing urbanisation and industrialization requirements for land are increasing. To meet this demand forests are cleared felled for settlements and for installation of industrial units.
- **Development projects**: Massive destruction of forests is done for various development projects like hydroelectric projects, road construction, mining etc.
- **Overgrazing**: The poor in the tropics mainly rely on wood as a source of fuel leading to loss of tree cover and the cleared lands are turned into the grazing lands. Overgrazing by the cattle leads to further degradation of these lands.
- **Forest fires**: Natural and manmade forest fires are very common happenings in certain areas. These fires, whether natural or manmade, cause huge damages to the forests world over.

3.3.6. Consequences of Deforestation

Forests are very important natural resources. The economic and ecological significance of forests is undisputable. Deforestation has far reaching consequences, both environmental as well as economic. Some of the major consequences are outlined as below:

Loss of wildlife: There are millions of animal and plant species living in forests. Deforestation has threatened them all as they are not able to survive when their habitat has been destroyed.

Biodiversity loss: Forests house huge biodiversity. Deforestation simply means the destruction and extinction of many plants and animal species. This is the most serious consequence of deforestation.

Displacement of indigenous communities: Many indigenous groups of people live in and around forests. They draw all of their needs and necessities from nearby forests. Their survival stands threatened by the loss of forests.

Climate change: Deforestation can cause the climate to become extreme in nature. It increases CO2 concentration in atmosphere and contributes to global warming.

Economic losses: the ecological services of forests are innumerable. They play role in hydrological cycle. They help tackling flood and drought problems. When there are no forests to serve these purposes, the economic losses due to floods and droughts become a huge burden on a nation's economy.

Soil degradation: Due to loss of forest cover soil erosion increases and its fertility declines.

Landslides: In hilly areas deforestation leads to many local problems. It increases the occurrence of landslides and floods.

3.4. WATER RESOURCES

Water is essential for human survival and well-being and important to many sectors of the economy. Uses of water include agricultural, industrial, household, recreational and environmental activities. The majority of human uses require fresh water. However, resources are irregularly distributed in space and time, and they are under pressure due to human activity.

97 percent of the water on the Earth is salt water and only three percent is fresh water. Only 3% of the Earth's water is fresh water. Most of it is in icecaps and glaciers (69%) and groundwater (30%), while all lakes, rivers and swamps combined only account for a small fraction (0.3%) of the Earth's total freshwater reserves.

Water: A Unique Liquid

Water is characterized by certain unique features which make it a marvellous resource:

- It exists as a liquid over a wide range of temperature i.e. from 0° to100°C.
- It has the highest specific heat, due to which it warms up and cools down very slowly without causing shocks of temperature jerks to the aquatic life.
- It has a high latent heat of vaporization. Hence, it takes a huge amount of energy for getting vaporized. That's why it produces a cooling effect as it evaporates.
- It is an excellent solvent for several nutrients. Thus, it can serve as a very good carrier of nutrients, including oxygen, which are essential for life. But, it can also easily dissolve various pollutants and become a carrier of pathogenic microorganisms.
- Due to high surface tension and cohesion it can easily rise through great heights through the trunk even in the tallest of the trees like Sequoia.
- It has anomalous expansion behaviour i.e. as it freezes, it expands instead of contracting and thus becomes lighter. It is because of this property that even in extreme cold, the lakes freeze only on the surface. Being lighter the ice keeps floating, whereas the bottom waters remain at a higher temperature and therefore, can sustain aquatic organisms even in extreme cold.

Fresh water is a renewable resource, yet the world's supply of groundwater is steadily decreasing, with depletion occurring most prominently in Asia and North America, although it is still unclear how much natural renewal balances this usage, and whether ecosystems are threatened.

3.4.1. Sources of water

Surface water: Surface water is water in a river, lake or fresh water wetland. Surface water is naturally replenished by precipitation and naturally lost through discharge to the oceans, evaporation, evapotranspiration and groundwater recharge.

Although the only natural input to any surface water system is precipitation within its watershed, the total quantity of water in that system at any given time is also dependent on many other factors. These factors include storage capacity in lakes, wetlands and artificial reservoirs, the permeability of the soil beneath these storage bodies, the runoff characteristics of the land in the watershed, the timing of the precipitation and local evaporation rates. All of these factors also affect the proportions of water loss.

Brazil is the country estimated to have the largest supply of fresh water in the world, followed by Russia and Canada.

Groundwater: Groundwater is fresh water located in the subsurface pore space of soil and rocks. It is also water that is flowing within aquifers below the water table. Sometimes it is useful to make a distinction between groundwater that is closely associated with surface water and deep groundwater in an aquifer (sometimes called "fossil water"). About 9.86% of the total fresh water resources are in the form of groundwater and it is about 35-50 times that of surface water supplies. Till some time back groundwater was considered to be very pure but now even groundwater aquifers have been found to be polluted.

A layer of sediment or rock that is highly permeable and contains water is called an **aquifer**. Layers of sand and gravel are good aquifers while clay and crystalline rocks (like granite) are not since they have low permeability. Aquifers may be of two types:

Unconfined aquifers which are overlaid by permeable earth materials and they are recharged by water seeping down from above in the form of rainfall and snow melt.

Confined aquifers which are sandwiched between two impermeable layers of rock or sediments and are recharged only in those areas where the aquifer intersects the land surface. Sometimes the recharged area is hundreds of kilometres away from the location of the well. Groundwater is not static, it moves, though at a very slow rate of about a meter or so in a year.

3.4.2 Uses of Water

I. Irrigational use: It is estimated that 70% of worldwide water is used for irrigation, It takes around 2,000 - 3,000 litres of water to produce enough food to satisfy one person's daily dietary need. This is a considerable amount, when compared to that required for drinking, which is between two and five litres. To produce food for the now over 7 billion people who inhabit the planet today requires the water that would fill a canal ten metres deep, 100 metres wide and 2100 kilometres long.

Around fifty years ago, there were half of the current number of people on the planet. People were not as wealthy as today, consumed fewer calories and ate less meat, so less water was needed to produce their food. They required a third of the volume of water we presently take from rivers. Today, the competition for water resources is much more intense. In the future, even more water will be needed to produce food because the Earth's population is forecast to rise to 9 billion by 2050.

About a fifth of the world's people, more than 1.2 billion, live in areas of physical water scarcity, where there is not enough water to meet all demands. One third of the world's population does not have access to clean drinking water, which is more than 2.3 billion people. To avoid a global water crisis, farmers will have to strive to increase productivity to meet growing demands for food, while industry and cities find ways to use water more efficiently.

As global populations grow, and as demand for food increases in a world with a fixed water supply, there are efforts under way to learn how to produce more food with less water, through improvements in irrigation methods and technologies, agricultural water management, crop types, and water monitoring. Aquaculture is a small but growing agricultural use of water.

II. Industrial use: It is estimated that 22% of worldwide water is used in industry. Major industrial users include hydroelectric dams, ore and oil refineries, which use water in chemical processes, and manufacturing plants which use water as a solvent. Water withdrawal can be very high for certain industries, but consumption is generally much lower than that of agriculture.

Water withdrawal: Taking water from groundwater or surface water resource

Water Consumption: The water which is taken up but not returned for reuse.

Globally, only about 60 percent of the water withdrawn is consumed due to loss through evaporation.

Hydroelectric power derives energy from the force of water flowing downhill, driving a turbine connected to a generator. This hydroelectricity is a low-cost, non-polluting, renewable energy source. Hydroelectric power plants generally require the creation of a large artificial lake. Evaporation from this lake is higher than evaporation from a river due to the larger surface area exposed to the elements, resulting in much higher water consumption.

Water is also used in many large scale industrial processes, such as thermoelectric power production, oil refining, and fertilizer production and other chemical plant use, and natural gas extraction from shale rock. Discharge of untreated water from industrial uses is pollution. Pollution includes discharged solutes (chemical pollution) and increased water temperature (thermal pollution). Thermoelectric power plants using cooling towers have high consumption, nearly equal to their withdrawal, as most of the withdrawn water is evaporated as part of the cooling process.

III. Household uses: It is estimated that 8% of worldwide water use is for household purposes. These include drinking water, bathing, cooking, toilet flushing, cleaning, laundry and gardening. Basic household water requirements have been estimated by Peter Gleick at around 50 litres per person per day, excluding water for gardens. Drinking water is water that is of sufficiently high quality so that it can be consumed or used without risk of immediate or long term harm. Such water is commonly called potable water.

3.4.3 Over-exploitation of Water Resources

Water is a precious natural resource. It requires judicious use as its availability varies from place to place and from time to time. Overexploitation of surface as well as ground water has detrimental effects on its future availability and on local environment. Excess extraction of ground water results in various types of geological and ecological complications which are detrimental to life. When groundwater withdrawal is more than its recharge rate, the sediments in the aquifer get compacted, a phenomenon known as ground subsidence.

Mining of groundwater done in arid and semi-arid regions for irrigating crop

Fields may cause a sharp decline in future agricultural production, due to lowering of water table.

3.4.4 Conservation of Water

Water conservation includes the policies, strategies and activities made to manage fresh water as a sustainable resource to meet current and future human demand.

Water conservation strategies

In implementing water conservation principles, there are a number of key activities that may be beneficial.

1. Reduction in water loss, use and waste of resources.
2. Avoiding any damage to water quality.
3. Improving water management practices that reduce or enhance the beneficial use of water.

Some other activities aiming at water conservation at household level are as follows:

- Low-flow shower heads sometimes called energy-efficient shower heads as they also use less energy
- Low-flush toilets and composting toilets. These have a dramatic impact in the developed world, as conventional Western toilets use large volumes of water
- Dual flush toilets created by Caroma includes two buttons or handles to flush different levels of water. Dual flush toilets use up to 67% less water than conventional toilets
- Faucet aerators, which break water flow into fine droplets to maintain "wetting effectiveness" while using less water. An additional benefit is that they reduce splashing while washing hands and dishes
- Raw water flushing where toilets use sea water or non-purified water
- Waste water reuse or recycling systems, allowing:
  - Reuse of gray water for flushing toilets or watering gardens
  - Recycling of wastewater through purification at a water treatment plant. See also Wastewater - Reuse
- Rainwater harvesting
- Use of high-efficiency clothes washers
- Weather-based irrigation controllers
- Low flow taps in wash basins

3.4.5 Rain Water Harvesting

It is a water conservation practice that involves capturing of rain where it falls or capturing of the runoff water after or during a rainfall. In general, water harvesting is the activity of direct collection of rainwater. The rainwater collected can be stored for direct use or can be recharged into the groundwater. Rain is the first form of water that we know in the hydrological cycle, hence is a primary source of water for us. Rivers, lakes and groundwater are all secondary sources of water. In present times, we depend entirely on such secondary sources of water. In the process, it is forgotten that rain is the ultimate source that feeds all these secondary sources and remain ignorant of its value. Water harvesting means to understand the value of rain, and to make optimum use of the rainwater at the place where it falls. Therefore, water harvesting can be undertaken through a variety of ways such as:

- Capturing runoff from rooftops
- Capturing runoff from local catchments
- Capturing seasonal floodwaters from local streams
- Conserving water through watershed management

The rain water harvesting can serve the following purposes:

- Provide drinking water
- Provide irrigation water
- Increase groundwater recharge
- Reduce urban floods and overloading of sewage treatment plants
- Reduce seawater ingress in coastal areas.

The total amount of water that is received in the form of rainfall over an area is called the **rainwater endowment** of the area. Out of this, the amount that can be effectively harvested is called the **water harvesting potential**.

The collection efficiency accounts for the fact that all the rainwater falling over an area cannot be effectively harvested, because of evaporation, spillage etc. Factors like runoff coefficient and the first-flush wastage are taken into account when estimated the collection efficiency.

3.4.6. Watershed Management

A **watershed** is a geographic area through which water flows across the land and drains into a common water body like river, lake, or ocean.

Watershed management is an adaptive, comprehensive, integrated multi-resource management planning process that seeks to balance healthy ecological, economic, and cultural/social conditions within a watershed. The goal of watershed management is to properly balance and manage this resource. Three types of benifits expected from healthy management of a watershed area are:

A. Ecological health: A healthy watershed functions as a complete ecological system promoting the health of all living organisms and landscapes within the watershed. A healthy, intact watershed minimizes the impacts of flooding and erosion and serves to filter sediments and contaminants so they do not reach our streams, lakes, and groundwater.

B. Economic health: An abundant supply of clean water is essential for a vibrant economy. Homes, farms, municipalities and businesses all need an ample supply of clean water to operate effectively. Clean water allows municipalities, businesses, agricultural producers, and industries to operate more cost effectively, saving money for taxpayers and consumers. Healthy rivers, lakes, wetlands and natural spaces are foundations for recreation and tourism.

C. Human health: Life requires a safe daily supply of water. But water is far more than that: clean surface and ground water is essential to support our high quality of life and the social aspects of our communities. Clean rivers, lakes and streams provide many healthy recreational opportunities including swimming, boating and fishing.

Watershed management involves a proper planning in order achieve the above said goals. It involves

1. Assessing the nature and status of the watershed
2. Identifying the watershed issues
3. Defining the short and long-term objectives
4. Enumerating the goals and designing of action plan
5. Implementing the action plan

General objectives of watershed management programs are:

- To protect, conserve and improve the land of watershed for more efficient and sustained production.
- To protect and enhance the water resource originating in the watershed.
- To check soil erosion and to reduce the effect of sediment yield on the watershed.
- To rehabilitate the deteriorating lands.
- To moderate the floods peaks at downstream areas.
- To increase infiltration of rainwater.
- To improve and increase the production of timbers, fodder and wild life resource.
- To enhance the ground water recharge, wherever applicable.
- To reduce the occurrence of floods and the resultant damage by adopting strategies for flood management.
- To provide standard quality of water by encouraging vegetation and waste disposal facilities.

These objectives are achieved through set of measures undertaken under Watershed Management Action Plan. The measures or practices to be adopted in the watershed management include:

- **Vegetative measures** (Agronomical measures)
  - Strip cropping
  - Pasture cropping
  - Grass land farming
  - Wood lands
- **Engineering measures** (Structural practices)
  - Contour bunding
  - Terracing
  - Construction of earthen embankment
  - Construction of check dams
  - Construction of farm ponds

- o Construction of diversion
- o Gully controlling structure
- **Afforestation**
  - o Plantation of fast growing species
  - o Fuel wood plantation

3.5 FOOD RESOURCES

Human body needs food for survival and development. Food is, thus, any substance consumed to provide nutritional support for the body. It is usually of plant or animal origin, and contains essential nutrients, such as fats, proteins, vitamins, or minerals. The substance is ingested by an organism and assimilated by the organism's cells to provide energy, maintain life, or stimulate growth. A large number of items are consumed by human either in their natural states or after proper processing and cooking. Vitamins, proteins carbohydrates and minerals are primarily obtained from cereals, fruits, vegetables, pulses and spices. Milk, butter, meat and eggs are obtained from different types of animals. The source of much of the food consumed by man is terrestrial agriculture.

There are two main types of agriculture (1) Crop agriculture in which plant production is harvested for use by man and (2) Animal agriculture where a crop from highly manipulated ecosystem is fed to domesticated animals.

In general a strong and healthy human consumes about 1.4 kg of food every day. Such a food serves as a source of energy and replacement of uses. Food consumption patterns vary from region to region and from population to population. The most important feature is that rice to the staple food for most Asians.

3.5.1 Sources of Food

Most food has its origin in plants. Some food is obtained directly from plants; but even animals that are used as food sources are raised by feeding them food derived from plants. Cereal grain is a staple food that provides more food energy worldwide than any other type of crop. Corn (maize), wheat, and rice – in all of their varieties – account for 87% of all grain production worldwide. Some foods not from animal or plant sources include various edible fungi, especially mushrooms. Fungi and ambient bacteria are used in the preparation of fermented and pickled foods like leavened bread, alcoholic drinks, cheese, pickles, kombucha, and yogurt. Inorganic substances such as salt, baking soda and cream of tartar are used to preserve or chemically alter an ingredient.

Plants

Many plants and plant parts are eaten as food and around 2,000 plant species are cultivated for food. Many of these plant species have several distinct cultivars.

Seeds of plants are a good source of food for animals and humans because they contain the nutrients necessary for the plant's initial growth, including many healthful fats, such as Omega fats. In fact, the majority of food consumed by human beings is seed-based foods. Edible seeds include cereals (corn, wheat, rice, et cetera), legumes (beans, peas, lentils, et cetera), and nuts. Oilseeds are often pressed to produce rich oils - sunflower, flaxseed, rapeseed (including canola oil), sesame, et cetera.

Fruits are the ripened ovaries of plants, including the seeds within. Fruits, therefore, make up a significant part of the diets of most cultures. Some botanical fruits, such as tomatoes, pumpkins, and eggplants, are eaten as vegetables. Vegetables are a second type of plant matter that is commonly eaten as food. These include root vegetables (potatoes and carrots), bulbs (onion family), leaf vegetables (spinach and lettuce), stem vegetables (bamboo shoots and asparagus), and inflorescence vegetables such as cabbage or cauliflower.

Animals

Animals are used as food either directly or indirectly by the products they produce. Meat is an example of a direct product taken from an animal, which comes from muscle systems or from organs.

Food products produced by animals include milk produced by mammary glands, which in many cultures is drunk or processed into dairy products (cheese, butter, etc.). In addition, birds and other animals lay eggs, which are often eaten, and bees produce honey, reduced nectar from flowers, which is a popular sweetener in many cultures.

Most food has always been obtained through agriculture. With increasing concern over both the methods and products of modern industrial agriculture, there has been a growing trend toward sustainable agricultural practices.

A healthy diet is one that helps maintain or improve overall health. Nutrients in food are grouped into several categories. Macronutrients are fat, protein, and carbohydrates. Micronutrients are the minerals and vitamins. Additionally, food contains water and dietary fiber.

A healthy diet provides the body with essential nutrition: fluid, adequate essential amino acids from protein, essential fatty acids, vitamins, minerals, and adequate calories. Various nutrition guides are published by medical and governmental institutions to educate the public on what they should be eating to promote health. Nutrition facts labels are also mandatory in some countries to allow consumers to choose between foods based on the components relevant to health.

The World Health Organization (WHO) makes the following 5 recommendations with respect to both populations and individuals:

- Eat roughly the same amount of calories that your body is using. A healthy weight is a balance between energy consumed and energy that is 'burnt off'.
- Limit intake of fats, and prefer less unhealthy unsaturated fats to saturated fats.
- Increase consumption of plant foods, particularly fruits, vegetables, legumes, whole grains and nuts.
- Limit the intake of sugar.
- Limit salt / sodium consumption from all sources and ensure that salt is iodized.

Other recommendations may also be added to this list such as:

- Essential micronutrients such as vitamins and certain minerals.
- Avoiding directly poisonous (e.g. heavy metals) and carcinogenic (e.g. benzene) substances.
- Avoiding foods contaminated by human pathogens (e.g. E. coli, tapeworm eggs).

Deficiencies, excesses, and imbalances in diet can produce negative impacts on health, which may lead to various health problems such as scurvy, obesity, or osteoporosis, diabetes, cardiovascular diseases as well as psychological and behavioural problems. The science of nutrition attempts to understand how and why specific dietary aspects influence health.

3.5.2. World Food Problems

The Food and Agriculture Organization (FAO) of United Nations shows that on an average the minimum caloric intake on a global scale is 2,500 calories/day. People receiving less than 90% of these minimum dietary calories are called **undernourished** and if it is less than 80% they are said to be **seriously undernourished**. Deficiency or lack of nutrition often leads to malnutrition resulting in several diseases.

Availability of food to human population is a global problem at present. Though world grain production has increased almost three times but, at the same time population growth increased at such a high rate that it outstripped food production. Every year 40 million people (fifty percent of which are young children below 5 years) die of undernourishment and malnutrition. Expanding population is the major cause of world food problem. The problem is much serious in developing and under developed countries of Asia and Africa. In some parts traditional agricultural systems are still prevalent which are inefficient to meet the food requirements of the ever increasing populations.

It has been conduced that even if the rapid development of conventional agriculture is sustained protein deficiency will continue to exist.

Food safety and food security are monitored by agencies like the International Association for Food Protection, World Resources Institute, World Food Programme, Food and Agriculture Organization, and International Food Information Council. They address issues such as sustainability, biological diversity, climate change, nutritional economics, population growth, water supply, and several organisations have begun calling for a new kind of agriculture in which agroecosystems provide food but also support vital ecosystem services so that soil fertility and biodiversity are maintained rather than compromised. According to the International Water Management Institute and UNEP, well-managed agroecosystems not only provide food, fiber and animal products, they also provide services such as flood mitigation, groundwater recharge, erosion control and habitats for plants, birds fish and other animals.

3.5.3 Indian Scenario

India has only half as much land as USA, but it has nearly three times population to feed. Our food problems are also related to population. Although India is the third largest producer of staple crops, an estimated 300 million Indians are still undernourished.

3.5.4 Environmental Impacts of Modern Agriculture

Modern agriculture has greatly helped us meet food requirements of increasing population. But excessive agricultural production has also badly affected the environment and soil. Extensive agriculture has depleted soil fertility. Use of synthetic fertilizers has caused micronutrient imbalance in soils. These fertilizers, pesticides and weedicides cause serious pollution problem in water bodies besides affecting soil. Use of genetically engineered and high yielding varieties cause many other ecological problems.

Extensive and intensive agriculture has also resulted in salinisation and water logging of soil in many areas.

The serious environmental implications associated with modern agriculture ask for a rethink on it.

3.5.5. Sustainable Agriculture

In view of the serious negative effects of modern agriculture we have to shift towards a more sustainable form of agriculture. Our dependence on synthetic fertilizers has degraded soils. Use of a handful of high yield varieties has encouraged monoculture which is always susceptible to diseases and climatic adversaries. Use of chemical pesticides has caused serious environmental issues. Now we have to adopt an environment friendly and sustainable agriculture which so that we can meet our present needs without compromising our future. The term sustainable agriculture has been described as an integrated system of plant and animal production practices having a site-specific application that will, over the long term:

- satisfy human food and fiber needs;

- enhance environmental quality and the natural resource base upon which the agricultural economy depends;
- make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls;
- sustain the economic viability of farm operations; and
- enhance the quality of life for farmers and society as a whole."

Sustainable agriculture refers to adopting the agricultural practices which do not threat our environment. It aims at production of food, fiber, or other plant or animal products using farming techniques that protect the environment, public health, human communities, and animal welfare. Sustainable agriculture includes switching over to traditional farm practices which can be modified to suit the present requirements. It also encourages low energy consumption and less generation of wastes. Sustainable farming practices commonly include:

- Crop rotations that mitigate weeds, disease, insect and other pest problems; provide alternative sources of soil nitrogen; reduce soil erosion; and reduce risk of water contamination by agricultural chemicals
- Pest control strategies that are not harmful to natural systems, farmers and consumers. This includes integrated pest management techniques that reduce the need for pesticides by practices such as scouting, use of resistant cultivars, timing of planting, and biological pest controls
- Increased mechanical/biological weed control; more soil and water conservation practices; and strategic use of animal and green manures
- Use of natural or synthetic inputs in a way that poses no significant hazard to man, animals, or the environment.
- Use of bio fertilizers such as green manure, farmyard manure and nitrogen fixing crops instead of fertilizers
- Adopting traditional farming techniques which help conserve soil and its fertility
- Adoption of poly culture instead of monoculture crops
- Use of alternative and renewable sources of energy wherever possible

3.6 ENERGY RESOURCES

Almost all the developmental activities of modern society are directly or indirectly dependent upon energy. Energy consumption of a nation is usually considered as an index of its development. There is clear difference in per capita energy use between the developed and the developing nations. Utilization of energy probably first started when primitive man learnt to use fire which produced heat and the early man used it for cooking and heating purposes. Wind and hydropower have also been in use for the in the traditional society. The invention of steam engines replaced the burning of wood by coal and coal was later replaced to a great extent by oil.

3.6.1 Growing Energy Needs

Modern society heavily relies upon various forms of energy. Development in different sectors is dependent on the availability of ample amounts of energy. Be it agriculture, industry, mining, transportation or lighting all need energy. The fossil fuels like coal, oil and natural gas supply about 95% of the commercial energy in the world. With growing populations, industrialization and other developmental sectors demands for energy is increasing world over.

Our changing life style and quest for a more and more luxurious life has further increased the demand of energy. Increasing numbers of electric gadgets in our homes and rising number of cars in our localities demand increased amounts of energy with every passing day

The consumption and demand of energy is much higher in developed countries. Countries like U.S.A. and Canada constitute only 5% of the world's population but consume 25% of global energy resources. Energy consumption of a single person in these countries is about 300 GJ (Giga Joules) per year. Whereas an average man in a poor country like Bhutan, Nepal or Ethiopia consumes less than 1 GJ in a year. So a person in a rich country consumes almost as much energy in a single day as one person does in a whole year in a poor country. This clearly depicts that our modernised way of life needs much more energy. it indicates very high demands of energy in the world in future as the world as a whole is shifting from a simple way of life to a modern and sophisticated way of life. Thus there is very high pressure on the existing conventional sources of energy. But, unfortunately, these sources of energy are not going to last forever.

3.6.2 Sources of Energy

A source of energy is a substance or means that can provide adequate amount of energy in a usable form over a long period of time. These sources can be of two types:

A. Renewable Energy Resources are those which can generate energy continuously in nature and are inexhaustible or regenerable e.g. wood, solar energy, wind energy, tidal energy, hydropower, biomass energy, bio-fuels, geo-thermal energy and hydrogen. They are also known as non-conventional sources of energy and they can be used again and again in an endless manner. A brief discussion on various renewable sources of energy is given below

B. Non-renewable Energy Resources are those which have accumulated in nature over a long span of time and cannot be quickly replenished when exhausted e.g. coal, petroleum, natural gas and nuclear fuels like uranium and thorium.

A. Renewable Energy Resources

1. **Wood or Dendrothermal Energy:** Wood is a renewable source of energy. It gives immense heat on burning that can be used for various purposes. Different types of wood or plant species give different amount of energy per unit of wood burnt.

   Solar energy: Sun is the ultimate source of energy, directly or indirectly on our planet. The nuclear fusion reactions occurring inside the sun release enormous quantities of energy in the form of heat and light. The solar energy received by the near earth space is approximately 1.4 kilojoules/second/m2. This is also known as **solar constant**. We have developed several techniques for harnessing solar energy. Solar energy has successfully been used in solar water heaters, solar cookers, photovoltaic cells or PV cells and solar power plants.

2. **Wind Energy:** It refers to the kinetic energy present in high speed winds due to their. The wind energy is harnessed by making use of wind mills. The blades of the wind mill keep on rotating continuously due to the force of the striking wind. The rotational motion of the blades can be used to drive a number of machines like electric generators, flour mills and water pumps. A large number of wind mills are installed in clusters called wind farms, which are used to produce a large amount of electricity.

   The minimum wind speed required for satisfactory working of a wind generator is 15 km/hr.

Big Dams: Benefits and Problems

Water is used for various purposes in our daily life and in industrial sectors. River valley projects with big dams have usually been considered to play a key role in the development process due to their multiple uses. India has the distinction of having the largest number of river-valley projects. The dams have tremendous potential for economic upliftment and growth. They can help in checking floods and famines, generate electricity and reduce water and power shortage, provide irrigation water to lower areas, provide drinking water in remote areas and promote navigation, fishery etc.

There are various environmental implications associated with big dams constructed for hydroelectric power generation and irrigation. These include:

1. *Displacement of tribal people*
2. *Loss of forests and biodiversity*
3. *Changes in fisheries and the spawning grounds*
4. *Siltation and sedimentation of water reservoirs*
5. *Loss of land*
6. *Water logging in areas near reservoir*
7. *Breeding of disease causing agents or pathogens and spread of vector-borne diseases*
8. *Reservoir induced seismicity (RIS) causing earthquakes in the region.*
9. *Microclimatic changes.*
10. *Reduced water flow and silt deposition in river*
11. *Flash floods*
12. *Salt water intrusion at river mouth*

Owing to these serious side effects of big dams there is a shift towards construction of small dams or mini-hydel projects.

The wind power potential of our country is estimated to be about 20,000 MW, while at present we are generating about 1020 MW.

Wind energy is an environment friendly form of energy as it does not cause any air pollution.

After the initial installation cost, the wind energy is also very cheap.

3. **Hydropower:** It refers to the generation of electricity from water. In this process kinetic energy of water is converted to electric energy through the use of turbine and other devices. The water flowing in a river is collected and stored in a big dam. This water is then allowed to fall from a height and rotate a turbine connected with a generator to produce electricity.

   Due to side effects of big dams it is more appropriate to construct mini or micro hydel power plants on the rivers in hilly regions for harnessing the hydro energy on a small scale to meet local energy needs. It does not cause any pollution and is renewable source of energy.

   The hydropower potential of India is estimated to be about 4 × 1011 KW-hours. Till now we have utilized only a little more than 11% of this potential.

4. **Tidal Energy:** It refers to the energy present in oceans due to gravitational effects of sun and moon. Rise and fall of water in seas and oceans is known as high tide and low tide. The tidal energy can be harnessed by constructing a tidal barrage. During high tide, the sea-water flows into the reservoir of the barrage and turns the turbine placed there, which in turn produces electricity by rotating the generators. During low tide, when the sea-level is low, the sea water stored in the barrage reservoir flows back into the sea and again turns the turbines. Thus electricity can be generated using tidal energy of the oceans

   Tidal energy is, however, not available everywhere and there are very few sites in the world where it can be effectively harnessed for useful purposes.

5. **Geothermal Energy:** The energy harnessed from the heat produced inside the earth is called geothermal energy. There is high pressure and temperature inside the earth. At some places, the steam or the hot water comes out of the ground naturally through cracks in the form of natural geysers. Sometimes it does not find any place to come out and we can artificially drill a hole up to the hot rocks and by putting a pipe in it make the steam or hot water gush out through the pipe at high pressure. It turns the turbine of a generator to produce electricity. There are several geothermal plants working successfully in certain countries of the world such as USA and New Zealand,

6. **Biomass Energy:** Biomass means the organic matter produced by the plants or animals. It includes wood, crop residues, cattle dung, manure, sewage, agricultural wastes etc. Biomass energy is of the following types:

(a) **Energy Plantations**: Several fast growing plants may be grown and then used for providing energy either by burning directly or by getting converted into burnable gas or may be converted into fuels by fermentation.

(b) **Petro-crops**: Certain latex-containing plants like Euphorbias and oil palms are rich in hydrocarbons and can yield oil like substance under high temperature and pressure. This oily material may be burned in diesel engines directly or may be refined to form gasoline. These plants are popularly known as petro-crops.

(c) **Agricultural and Other Waste Biomass**: In our homes in rural settings we burn various types of biomass in open or household furnaces called Chullahs to produce heat and cook food. Animal dung cakes are also commonly burnt to produce heat in rural areas. Crop residues, bagasse (sugarcane residues), coconut shells, peanut hulls, cotton stalks etc. are some of the common agricultural wastes which produce energy by burning. Animal dung, fishery and poultry waste and even human refuse are examples of biomass energy. In Brazil 30 % of electricity is obtained from burning bagasse. In rural India about 80 % of rural heat energy requirements are met by burning agricultural wastes, wood and animal dung cakes.

The direct burning of biomass in open often causes air pollution and produces a lot of ash as waste residue. It is therefore, more useful to convert the biomass into biogas or bio fuels.

(d) **Biogas:** Biogas is the burnable gas obtained from biomass in a particularly designed fermentation plant. It is a mixture of methane, carbon dioxide, hydrogen and hydrogen sulphide, the major constituent being methane. Biogas is produced by anaerobic degradation of animal and plant wastes in the presence of water. All wastes are directed to a dome shaped or other structure made for the purpose. After sometime microbial action on biomass wastes i n presence of plenty of water produces biogas which can directly be used for cooking and heating purposes.

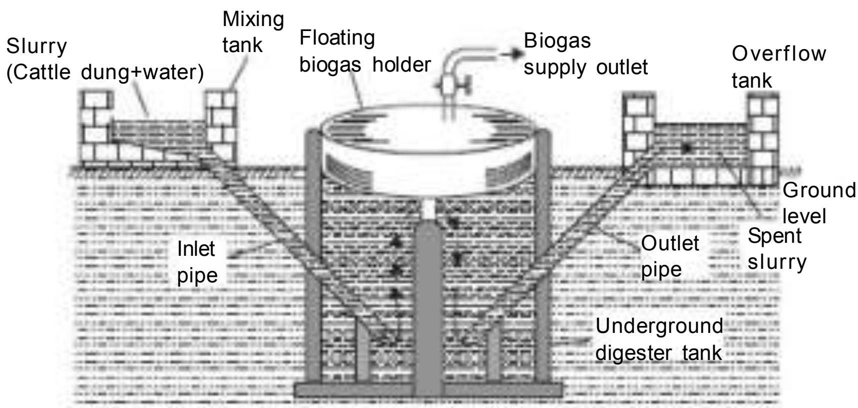


Fig. 3.1. Floating Biogas Plant (Source: Kaushak and Kaushak, 2006)

Biogas is a non-polluting, clean and low cost fuel which is very useful for rural areas where a lot of animal waste and agricultural waste are available. The sludge left over after use of gas from plant is a rich fertilizer containing bacterial biomass with most of the nutrients preserved as such.

B. Non Renewable Sources of Energy

Fossil fuels like coal, petroleum and natural gas are the major sources of energy in the present world. They are used as fuels and are non renewable. These were formed by the decomposition of the remains of plants and animals buried under the earth millions of years ago. Nuclear energy is another form which is very effective but has also its own demerits.

1. **Coal:** Coal is the most abundant fossil fuel in the world. There are mainly three types of coal, namely anthracite (hard coal), bituminous (Soft coal) and lignite (brown coal). Anthracite coal has maximum carbon (90%) and calorific value (8700 kcal/kg.) Bituminous, lignite and peat contain 80, 70 and 60% carbon, respectively.

   India has about 5% of world's coal though Indian coal is not very good in terms of heat capacity. Major coal fields in India are Raniganj, Jharia, Bokaro, Singrauli, and Godavari valley.

   Anthracite coal occurs only in our state i. e J & K in India.

   On burning coal causes serious environmental pollution including release of carbon dioxide a major green house gas.

2. **Petroleum:** It is the most important energy source in the world. There are 13 countries in the world having 67% of the petroleum reserves which together form the OPEC (Organization of Petroleum exporting countries). About $1/4^{th}$ of the oil reserves are in Saudi Arabia.

   Crude petroleum is a complex mixture of alkane hydrocarbons. Hence it has to be purified and refined by the process of fractional distillation, during which process different constituents separate out at different temperatures and we get a large variety of products from this, namely, petroleum gas, kerosene, petrol, diesel, fuel oil, lubricating oil, paraffin wax, asphalt, plastic etc. LPG we use at home is a liquefied form of petroleum gas which mostly consists of Butane.

   In India in India oil fields are located at Digboi (Assam), Gujarat Plains and Bombay High, offshore areas in deltaic coasts of Gadavari, Krishna, Kaveri and Mahanadi.

   Petroleum also cause pollution on burning but it is cleaner than coal as it left no residue after burning.

3. **Natural gas:** It is also a fossil fuel. Natural gas deposits mostly accompany oil deposits because it has been formed by decomposing remains of dead animals and plants buried under the earth. It is mainly composed of methane (95%) with small amounts of propane and ethane. Natural gas is the cleanest fossil fuel. It can be

easily transported through pipelines. It has a high calorific value of about 50KJ/G and burns without any smoke.

Natural gas is used as a domestic and industrial fuel. It is used as a fuel in thermal power plants for generating electricity.

Compressed natural gas (CNG) is used as an alternative to petrol and diesel for transport of vehicles. It is much cleaner and causes no or very little pollution. In Delhi all buses and auto rickshaws run on this new fuel.

4. **Nuclear energy:** Nuclear energy is the tremendous energy present in the nucleus of an atom. This energy can be harnessed from the atoms of some elements and can be utilised for fulfilling energy requirements at large scale. It can be generated by two types of reactions:

Nuclear Fission: It is the nuclear change in which nucleus of certain isotopes with large mass numbers are split into lighter nuclei on bombardment by neutrons and a large amount of energy is released through a chain reaction. As in the example below Uranium atom is bombarded with a neutron and it releases huge amount of energy and Uranium atoms gets converted to Krypton and Barium.

$$92U235 + 0n1 \rightarrow 36Kr92 + 56Ba141 + 3\ 0n1 + \text{Energy}$$

Uranium-235 nuclei are most commonly used in nuclear reactors. Nuclear Reactors make use of nuclear chain reaction. Only 1 neutron is allowed to strike for splitting another nucleus in order to control the rate of fission.

Nuclear fusion: Here two isotopes of a light element are forced together at extremely high temperatures until they fuse together to form a heavier nucleus. This reaction also releases enormous energy in the process. It releases more energy than nuclear fission.

$$1H2 + 1H2 \rightarrow 3He2 + 0n1 + \text{Energy}$$

In the example shown above, two hydrogen (Deuterium) atoms fuse to form the nucleus of Helium at very high temperature. The process releases a neutron a huge amount of energy.

Nuclear energy has tremendous potential but very serious risks of leakage from nuclear reactor are associated with it. Disposal of the nuclear waste also poses a big problem.

There are several nuclear power stations in India located at Tarapur (Maharashtra), Kota (Rajasthan), Kalpakkam (Tamil Nadu) and Narora (U.P.). India has uranium from mines in Bihar. There are deposits of thorium in Kerala and Tamil Nadu.

Alternate Sources of Energy

Energy requirements are increasing day by day where as conventional sources of energy such as oil, coal and natural gas are very limited. This situation insists for use of non conventional sources of energy which can be renewed and thus be used again and again without fear of depleting them. The alternative non-conventional energy sources include all the renewable forms of energy as discussed in above section.

RECAPS AND PRACTICES

Walk and Talk

(Facts in Brief)

- The mean of satisfying humans' needs are called as Resources.
- A natural component of our environment like land, water, minerals, forests, wildlife, biodiversity, energy and even man himself are considered as Resources.
- World's densest forests are found in tropical regions (i.e on either side of the equator) which are warm and humid.
- Scientists believe that at least 33% of a country's geographic land should be under forest cover
- India has 27% of its total geographic area under forests as per official figures. But independent estimates say it's only around 22%.
- In J&K only 19% of geographic area is forest covered.
- Deforestation leads to
  - o Soil degradation and erosion
  - o Changes in climatic conditions
  - o Destruction of natural habitat and biodiversity
  - o Destruction of valuable sink for environmental pollutants
  - o Depletion of resources for obtaining fuel wood, timber wood and industrial raw materials.
- India has maximum of its forests in tropical moist deciduous forests(37% of its total forests)
- Water is the most vital resource for life.
- Though 71% earth's surface is covered, But available fresh water are very limited.
- 97.20% of total water on earth lies in oceans as salt water.
- 2.15% of total water is frozen as ice cops, glaciers etc.
- Only 0.65% of total water present on the earth is fresh water as surface or ground water
- An average human being requires about 2.70 liter clean water per day for drinking purposes.
- 60-70% of body weight of living organisms is due to water which is major component of cells.
- Water is the only inorganic liquid that exist in nature

- Average daily energy requirement of an individual varies with age, sex, profession and body weight.
- Food consumption of humans is measured in terms of calories which is a unit of heat energy
- Food that provides 2500 -3000 kilo calories per day is sufficient for an average individual.
- 200 kg of cereal/ year (food intake) is considered sufficient for an average human being.
- Diet should consist of all basic nutrients required. It is called a balance diet and should contain carbohydrates, fats, vitamins, and minerals.
- Most of world's energy comes from fossil fuels
- Worldwide oil is the dominant source of energy. It constitutes more than 38.10% of total energy consumed.
- Coal constitute 25.60 and natural gas 20.905 of primary fuels used worldwide.
- Use of Renewable energy constitutes only 8.90% o total primary energy consumption.
- There are about 600 sedimentary basins of crude oil in the world. 200 of them are unexplored as they lie in Polar Regions or deep water.
- Depending upon the carbon content there are three categories of coal viz- Anthracite, Bituminous and Lignite. Anthracite is the highest value.
- 56% of reserves of coal are in Russia and 28% lies in USA and Canada.
- 67% of oil reserves are in Asian countries (Middle East) and 15% lies in America.
- Alternate or non-conventional sources of energy include:-
    - o Wind energy.
    - o Energy from oceans.
    - o Tidal energy.
    - o Energy from waves.
    - o Thermal energy of ocean.
    - o Geo thermal energy.
    - o Direct use of solar energy.
    - o Biomass based energy.
    - o Biogas.
    - o Petro plants.
    - o Dendro-thermal.
- There are estimated 200 billion metric ton of coal reserves in India.
- Oil reserves are about 4.45 billion tones, only 775 million are recovered.
- Oil reserves in India are in Assam, Gujarat, Bombay high etc.

- India has a total land area about 2.40% of world but support more than 17% of world's population.
- Major land use categories in India are.
  - Cultivated land. = 142 Mha.
  - Forest land. = 67 Mha
  - Non agricultural land. = 20 Mha.
  - Barren and pasture land. = 55 Mha.
  - Fallow land. = 25Mha

Practice and Prepare

(Self Tests)

Choose the correct answer

1. Which among the following is not a natural resource
   a. Land b. Water
   c. Electricity d. Minerals **Ans. c**
2. Which is not a function performed by forests
   a. Maintain ecological balance b. regulating hydrological cycle
   c. Soil conservation d. Earthquake prevention **Ans. d**
3. India has maximum forest cover in
   a. Madhya Pradesh b. Jammu and Kashmir
   c. Uthrakhand d. Rajasthan **Ans. a**
4. .....% of a country's geographic area should be under forest
   a. 15% b. 33%
   c. 50% d. 42% **Ans. b**
5. J&K does not has this type of forest
   a. Tropical rain forests b. Temperate forests
   c. Broadleaved forests d. Coniferous forests **Ans. a**
6. Water is a
   a. Natural resource b. Man made resource
   c. Both of A and B d. None of the above **Ans. a**
7. Majority of water present on earth is
   a. Salt water b. Fresh water
   c. Ground water d. Water in ice caps and glaciers
   Ans. a

8. Rain water harvesting is
   a. A new concept b. A traditional concept
   c. An unwanted practice d. Disturbance in ecosystem **Ans. b**
9. Water Withdrawal is generally ......than Water Consumption
   a. Lower b. Higher
   c. Equal d. None of the above **Ans. b**
10. Excessive extraction of ground water may lead to
    a. Earthquake b. Subsidence
    c. Deforestation d. Landslides **Ans. b**
11. .... is provides the maximum fuel used worldwide at present
    a. Fuelwood b. Coal
    c. Oil d. Nuclear energy **Ans. b**
12. Eutrophication of water bodies may be caused by
    a. Use of pesticides b. Excessive use of fertilizers
    c. Deforestation d. Traditional agricultural practices
    Ans. b
13. Water logging and salinization in soil is caused by
    a. Drought b. Floods
    c. Over-irrigation d. Continuous rains **Ans. c**
14. Which one produces less environmental pollution
    a. Coal b. Petroleum
    c. CNG d. Diesel **Ans. c**
15. A balanced or healthy diet must contain
    a. Carbohydrates b. Fats
    c. Minerals d. All of the above **Ans. d**
16. How much calories an average healthy person must take daily
    a. 1500 k cal b. 2200 k cal
    c. 2600 k cal d. 4000 k cal **Ans. c**
17. DDT that also cause pollution is
    a. A fertilizer b. A medicine
    c. A pesticide d. None of the above **Ans. c**

18. Developed countries like Canada & USA constitute world's 5% population but consume......of the world.
    a. 10% energy
    b. 50% energy
    c. 25% energy
    d. 5% energy
    Ans. c
20. Which among the following is a renewable source of energy
    a. Solar energy
    b. Hydro-electric energy
    c. Petroleum energy
    d. Nuclear energy
    Ans. a
21. Wind energy is a........source of energy
    a. Cheap and clean
    b. Expensive
    c. Unusable
    d. None of the above
    Ans. a
22. Major constituent of Biogas is
    a. Butane
    b. Carbon dioxide
    c. Ethane
    d. Methane
    Ans. d
23. Gully erosion is caused by
    a. Water
    b. Air
    c. Both A and B
    d. None of the above
    Ans. a
24. Nuclear energy involves
    a. No risks
    b. Cheap availability
    c. Simple handling
    d. None of the above
    Ans. d
25. Wood pulp is used for
    a. Lumber
    b. Plywood
    c. Paper
    d. Furniture
    Ans. c
26. Accumulation of toxic substances in food chain is called
    a. Bioaccumulation
    b. Food toxification
    c. Food web
    d. None of the above
    Ans. a
27. Jhum cultivation causes
    a. Water pollution
    b. Deforestation
    c. Health problems
    d. Energy crises
    Ans. b
28. Desertification is a
    a. Natural phenomenon
    b. Man made problem
    c. Land degradation
    d. All of the above
    Ans. d
29. India has a total land area equal to
    a. 329 million hectares
    b. 259 million hectares
    c. 250 million hectares
    d. 432 million hectares
    Ans. a

30. Which of the following is a cause of land degradation

a. Wrong farming practices
b. Deforestation
c. Pollution
d. All of the above

Ans. d

Chapter 4

Biodiversity and its Conservation

The value of biodiversity is more than the sum of its parts

Byran Norton

Objectives

In this unit, we will discuss the following:

- ✓ Biodiversity: Definition, meaning, levels and values
- ✓ Biodiversity at global and regional levels
- ✓ Endemic and Exotic Species
- ✓ Hotspots of Biodiversity
- ✓ Threats to Biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts
- ✓ Conservation of Biodiversity: In-situ and Ex-situ conservation

CHAPTER 4 BIODIVERSITY AND ITS CONSERVATION

Biodiversity starts in the distant past and it points toward the future.

Frans Lanting

ABSTRACT

Life originated as a single-celled organism on the earth. It gradually evolved from the simpler and smaller forms to the most complex and largest forms. Life took millions of years to evolve from the simpler to the complex forms and finally resulted into a huge of diverse forms of living organisms on the planet. This diverse world of living organisms around us is linked together within itself very intricately and systematically. It forms a support system which is not pivotal only for its own stability but is also extremely crucial for the mankind. This huge variety of life has always been used by man in different forms and for different purposes. Human life and civilization would have not been possible in isolation and away from nature or the other forms of life. Man has developed a close link with nature and other creatures. He valued nature and various forms of life in it for obtaining food, medicine, building and developmental materials and for cultural and religious purposes. He, however, in the recent centuries has started overexploiting nature and the variety of life present in it. This has led to great damages to the stable system of nature containing variety of life. This is ultimately bound to disturb the ecosystem stability and will lead man to suffer on various accounts.

INTRODUCTION

The term 'Biodiversity' is an acronym for 'biological diversity'. It refers to the variety and the variability of all the living organisms (plants, animals or microbes) present in an area. It is actually part of nature which shows differences at genetic, species or ecosystem level. Thus The term biodiversity encompasses variety of biological life at more than one scale. It is not only the variety of species (both plant and animal) but also the variety of genes within those species and the variety of ecosystems in which the species reside. Differences can be seen and studied among different individuals of same species, among different species in an ecosystem or area or among various ecosystems in a region.

In simpler words **Biodiversity** is the variety of life on the earth that includes variation at all levels of biological organisation from genes to species to ecosystems. Thus genetic, organismal and ecological diversity are all elements of biodiversity with each including a number of components and sub-components.

An important and widely used definition of Biodiversity is one given in the Convention on Biological Diversity which was signed by over 150 nations at the United Nations Conference on Environment and Development, at Rio de Janeiro, Brazil, in 1992. It defines biodiversity as:

"The variability among living organisms from all sources including, inter alia [among other things], terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems".

E. O. Wilson (1988) defines the term biodiversity as "the variety of life at every hierarchical level and spatial scale of biological organisations: genes within populations, populations within species, species within communities, communities within landscapes, landscapes within biomes, and biomes within the biosphere"

It is only a thin layer of just one kilomter thickness on the surface of the earth life exists. There occur millions of species of living organisms within this layer. There is a huge biodiversity present in different parts of the earth from the driest deserts to the densest tropical rain forests and from the high snow-clad mountain peaks to the deepest of ocean trenches.

This huge biodiversity present today is the result of 3.5 billion years of evolution since the first forms of life appeared on the earth.

There is no exact idea of how many different species of living organisms exists on the surface of the earth.

Scientists, however, believe it to be somewhere between **10 to 80 millions**

About 1.4 million species have so far been enlisted

Only 2.5 to 12% of the total number of species on the earth are described. Some estimates say that about 1.5 million living and 300,000 fossil species have been actually described and given scientific names. It is also believed that a large number of species may have become extinct even before they are discovered and scientifically studied.

Biodiversity is not distributed evenly or uniformly on the earth. It varies greatly across the globe as well as within regions. The richness of biodiversity depends on the climatic conditions and area of the region. Generally the tropical regions support more biodiversity than the polar regions. Biodiversity is much more on land than in oceans. Tropical rain forests are the richest in biodiversity. All species of plants taken together are known as **flora** and about 70,000 species of plants are known till date. All species of animals taken together are known as **fauna** which includes birds, mammals, fish, reptiles, insects, crustaceans, molluscs, etc

DETAILS AND DISCUSSIONS

4.1. LEVELS OF BIODIVERSITY

Biodiversity includes genetic variation within species, the variety of species in an area, and the variety of habitat types within a landscape. In order to understand biodiversity in an easier manner it can be studied at different scales or levels of biological organization. These include:

- Genetic Diversity
- Species Diversity
- Ecosystem Diversity

Genetic Diversity: Genetic diversity is the variety of genes within a species. Each species is made up of individuals that have their own particular genetic composition. They all differ from one another despite belonging to same species.

Genes are the basic units of all life on Earth. Genetic level diversity is the basic source of biodiversity. The genes found in organisms can form enormous number of combinations each of which gives rise to some variability. Each member of an animal or plant species differs from other individuals. It is because of their genetic makeup which differs slightly from individual to individual in the same species. All humans belong to same species *Homo sapiens* but they differ widely from one another. This is due to their genetic differences.

Within a species, genetic diversity give rise to a number of varieties or races or strains which slightly differ from each other in one, two or a number of characters such as shape, colour, strength, resistance to pests, etc.

Species diversity

Species diversity is the variety of species within a habitat or a region. The number of species of plants, animals and microorganisms that are present in a region constitutes its species diversity.

There are millions of living species present on the earth. A large number of species are also believed to have disappeared for ever even before their discovery. Some habitats, such as rainforests and coral reefs, have high species diversity that is there are found large number of species. Others, such as salt flats or a polluted stream, may not be rich in species diversity that is there may be fewer species present.

Ecosystem diversity

It refers the variety of ecosystems present in a region or on the whole of the earth.

There is a great variety of ecosystems on the earth. Each ecosystem has its own distinctive geographic and ecological features which support different types of life forms. This is, actually, the diversity of the ecological complexity showing variations in ecological niches, trophic structure, food-webs, nutrient cycling etc. The ecosystems show variations with respect to physical parameters like moisture, temperature, altitude, precipitation etc. Thus, there occurs tremendous diversity within the ecosystems, along these gradients.

The ecosystem diversity is of great value that must be kept intact. This diversity has developed over millions of years of evolution. If we destroy this diversity, it would disrupt the ecological balance. We cannot even replace the diversity of one ecosystem by that of another. Coniferous trees of boreal forests cannot take up the function of the trees of tropical deciduous forests and vice versa, because ecosystem diversity has evolved with respect to the prevailing environmental conditions with well regulated ecological balance.

Etymology of Term 'Biodiversity'

The term biological diversity was used first by wildlife scientist and conservationist Raymond F. Dasmann in the year 1968 lay book ***A Different Kind of Country*** advocating conservation. The term was widely adopted only after more than a decade, when in the 1980s it came into common usage in science and environmental policy. **Thomas Lovejoy**, in the foreword to the book ***Conservation Biology***, introduced the term to the scientific community. Until then the term "natural diversity" was common, introduced by The Science Division of The Nature Conservancy in an important 1975 study, "The Preservation of Natural Diversity." By the early 1980s TNC's Science program and its head, Robert E. Jenkins, Lovejoy and other leading conservation scientists at the time in America advocated the use of the term "biological diversity".

The term's contracted form *biodiversity* may have been coined by W.G. Rosen in 1985 while planning the 1986 *National Forum on Biological Diversity* organized by the National Research Council (NRC). It first appeared in a publication in 1988 when sociobiologist E. O. Wilson used it as the title of the proceedings of that forum.

Since this period the term has achieved widespread use among biologists, environmentalists, political leaders, and concerned citizens.

Source: Wikipedia

4.1.1 Measuring Biodiversity

In order to understand various aspects of biodiversity such as such as where it occurs, how fast it is disappearing or how it can be maintained; we need to be able to measure it.

- **Numbers or Magnitude:** It refers to the number of genes, populations, species or taxa in an area.
- **Evenness or Distribution:** Species evenness refers to how close in numbers each species in an environment is. Mathematically it is defined as a measure of biodiversity which quantifies how equal the community is numerically. So if there are 40 foxes, and 1000 dogs, the community is not very even. But if there are 40 foxes and 42 dogs, the community is quite even.
- **Difference or Range:** Some pairs of alleles, populations, species or taxa may be very similar whilst others are very different. For example, if populations within a species are very different they may be considered as different sub-species. Similarly in an ecosystem there may be 10 species of plants belonging to one or two genera whereas in another ecosystem there are 10 species of plant belonging to 10 different genera. The latter is considered more diverse.

Algorithms for measuring biodiversity have been developed to connote species diversity at different geographical scales as under:

Alpha Diversity

It indicates the number of species in a single community. The index can be used to compare the number of species in different ecosystem type. It is, thus also called as **local diversity**.

Beta Diversity

It indicates the degree to which species composition changes along an environmental gradient. It may also be referred to as the ratio between gamma (regional) and alpha (local) diversities.

Gamma Diversity

It indicates the rate at which additional species are encountered as geographical replacements within a habitat type in different localities. It is, thus, also called as **regional diversity**.

4.2. BIODIVERSITY AT GLOBAL LEVEL

Biodiversity is not distributed evenly across the globe. It varies greatly across the regions as well as within the regions. Besides other factors, the diversity of all living things (biota) depends on temperature, precipitation, altitude, soils, geography and the presence of other species in a region.

Though nobody knows how many species exist in the biosphere. Some estimates of different groups of living organisms are as follows:

- 220,000 vascular plants,
- 0.7-1 million marine species
- 10–30 million (of some 0.9 million we know today)
- 5–10 million bacteria
- 1.5-3 million fungi, Some 0.075 million species of fungi had been documented by 2001)
- 1 million mites

4.2.1. Mega-biodiversity regions of the world

A mega-biodiversity or megadiverse country is one that harbors the majority of the Earth's species and is therefore considered extremely bio-diverse. Conservation International identified 17 megadiverse countries in 1998. Many of them are located in, or partially in, tropical or **subtropical regions. In alphabetical order, the 17 megadiverse countries are:**

1. Australia
2. Brazil
3. China
4. Colombia
5. Democratic Republic of the Congo
6. Ecuador
7. India
8. Indonesia
9. Madagascar
10. Malaysia
11. Mexico
12. Papua New Guinea
13. Peru
14. Philippines
15. South Africa
16. United States
17. Venezuela

4.2.2. Biodiversity at Regional Level: India as a Mega-diverse Region

The great variety of ecological conditions prevailing in India, its location and climatic and physical features all favour an enormous diversity of life froms. India lies at the confluence of Ethiopian, Palaearctic and Indo-Malayan faunas. Its biodiversity is unique as it combines living forms from three major bio-geographical realms, namely – Eurasian, Agro-Tropical and Indo-Malayan regions. Its vegetation ranges from xerophytic in Rajasthan, evergreen in the North-East and the Ghats, mangroves of coastal areas, conifers of the hills and the dry deciduous forests of central India to alpine pastures in the high reaches of the Himalaya. Large number of species belonging to different taxonomic groups have been identified in India. They include:

- 15,000 species of flowering plants
- 53,430 species of insects;
- 5050 species of molluscs,
- 6,500 species of other invertebrates;
- 2,546 species of fishes;
- 1228 species of birds,
- 446 species of reptiles,
- 372 species of mammals and
- 204 species of amphibians have been identified in India.

Endemic Species of India

The species of animals or plants which are found in a particular area and are not found anywhere else are known as **Endemic species**. The feature of certain species being restricted to a particular region is called as **Endemism**.

India has two biodiversity hot spots and thus possesses a large number of endemic species. Out of about 47,000 species of plants in our country 7000 are endemic. Thus, Indian subcontinent has about 62% endemic flora, restricted mainly to Himalayas, Khasi Hills and Western Ghats. Some of the important endemic flora includes orchids and species like *Sapria himalayana, Uvaria lurida, Nepenthes khasiana, Pedicularis perroter* etc.

About 62% amphibians and 50% lizards are endemic to Western Ghats. Different species of monitor lizards (Varanus), reticulated python and Indian Salamander and Viviparous toad Nectophhryne are some important endemic species of our country.

Owing to its diverse geographic and climatic conditions India has a rich diversity of flora and fauna. About six percent of the earth's total number of living species are found in India. India ranks 10^{th} among the plant rich countries of the world, 11^{th} in terms of number of endemic species of higher vertebrates and 6^{th} among the centers of diversity and origin of agricultural crops.

The total number of living species identified in our country is about 150,000.

There are two hotspots of biodiversity in India-one the Western Ghats and the other eastern Himalayas.

4.3. ENDEMIC AND EXOTIC SPECIES

As stated above biodiversity is not similar everywhere on the surface of the earth. Some species of plants and animals are narrowly distributed in a limited geographic area. They do not exist anywhere else. Such species of plants and animals which are native to a particular area or region are known as endemic species of that region. Species can be endemic to large or small areas of the earth: some are endemic to a particular continent, some to part of a continent, and others to a single island or a small region. Chinar (Platinus orientalis) is endemic species of Kashmir. Box tree (Boxus walliciana) is endemic to PirPanjal region in India.

The extreme opposite of endemism is cosmopolitan distribution. So species which are distributed widely and are found almost everywhere are called as cosmopiltan species.

Exotic species are those species of plants or animals which are not native to an area but are introduced from outside. Exotic species may be introduced by man intentionally or may reach an area accidently or naturally. Eucalyptus is an exotic species in India. Such species are also known as **invasive species** when they widely grow and pose threat to the native species in an area.

4.4. VALUES OF BIODIVERSITY

Biodiversity is immensely important on the earth. It has direct as well indirect benifits for the mankind and for entire biosphere. We get benefits from other living organisms around us that is biodiversity in innumerable ways. Very small, insignificant, apparently useless organism may play a crucial role in the ecological balance of the earth. They may be a potential source of some invaluable drug for dreaded diseases. The values of biodiversity for its multiple uses, has been classified by McNeely et al in 1990 as recorded by Kaushak (2006):

A. **Consumptive Value:** These are direct use values where the biodiversity product can be harvested and consumed directly e.g. fuel, food, drugs, fibre etc.

1. **Food**: A large number of wild plants are consumed by human beings as food. About 80,000 edible plant species have been reported from wild. About 90% of present day food crops have been domesticated from wild tropical plants. Even now our agricultural scientists make use of the existing wild species of plants that are closely related to our crop plants for developing new hardy strains. Wild relatives usually possess better tolerance and hardiness. A large number of wild animals are also our sources of food.
2. **Drugs and medicines**: About 75% of the world's population depends upon plants or plant extracts for medicines. The wonder drug Penicillin used as an antibiotic is derived from a fungus called *Penicillium*. Likewise, we get Tetracyclin from a bacterium. Quinine, the cure for malaria is obtained from the bark of Cinchona tree, while Digitalin is obtained from foxglove (*Digitalis* spp) which is an effective cure for heart ailments. Recently vinblastin and vincristine, two anticancer drugs, have been obtained from Periwinkle (*Catharanthus*) plant, which possesses anticancer alkaloids. A large number of marine animals are supposed to possess anti-cancer properties which are yet to be explored systematically.
3. **Fuel**: Our forests have been used since ages for fuel wood. The fossil fuels coal, petroleum and natural gas are also products of fossilized biodiversity. Firewood collected by individuals is not normally marketed, but are directly consumed by tribals and local villagers, hence falls under consumptive value.

B. Productive Value: These are the commercially usable values where the product is marketed and sold. It may include lumber or wild gene resources that can be traded for use by scientists for introducing desirable traits in the crops and domesticated animals. These may include the animal products like tusks of elephants, musk from musk deer, silk from silk-worm, wool from sheep, fir of many animals, lac from lac insects etc, all of which are traded in the market.

Many industries are dependent upon the productive use values of biodiversity e.g.- the Paper and pulp industry, Plywood industry, Railway sleeper industry, Silk industry, Textile industry, Ivory-works, Leather industry, etc. Despite international ban on trade in products from endangered species, smuggling of fur, hide, horns, tusks, live specimen etc. Worth millions of dollars are being sold every year.

Developing countries in Asia, Africa and Latin America are the richest biodiversity centres and wild life products are smuggled and marketed in large quantities to some rich western countries and also to China and Hong Kong where export of cat skins and snake skins fetches a booming business.

Biodiversity when exploited for its consumptive and productive uses at large scale it is known to be its commercial use

C. Social Value: These are the values associated with the social life, customs, religion and psycho-spiritual aspects of the people. Many of the plants are considered holy and sacred in our country like Tulsi (holy basil), Peepal, Mango, Lotus, Bael etc. The leaves, fruits or flowers of these plants are used in worship or the plant itself is worshipped.

The tribal people are very closely linked with the wild life in the forests. Their social life, songs, dances and customs are closely woven around the wildlife. Many animals like Cow, Snake, Bull, Peacock, Owl etc. also have significant place in our psycho-spiritual arena and thus hold special social importance. Thus biodiversity has distinct social value, attached with different societies.

D. Ethical value: It is also sometimes known as existence value. It involves ethical issues like .all life must be preserved. It is based on the concept of .Live and Let Live.. If we want our human race to survive, then we must protect all biodiversity, because biodiversity is valuable.

The ethical value means that we may or may not use a species, but knowing the very fact that this species exists in nature gives us pleasure. We all feel sorry when we learn that passenger pegion or dodo is no more on this earth. We are not deriving anything direct from Kangaroo, Zebra or Giraffe, but we all strongly feel that these species should exist in nature. This means, there is an ethical value or existence value attached to each species.

E. Aesthetic value: Great aesthetic value is attached to biodiversity. No one of us would like to visit vast stretches of barren lands with no signs of visible life. People from far and wide spend a lot of time and money to visit wilderness areas where they can enjoy the aesthetic value of biodiversity and this type of tourism is now known as eco-tourism. The 'Willingness to pay' concept on such eco-tourism gives us even a monetary estimate for aesthetic value of biodiversity.

Ecotourism is estimated to generate about 12 billion dollars of revenue annually that roughly gives the aesthetic value of biodiversity.

F. **Option values:** These values include the potentials of biodiversity that are presently unknown and need to be explored. There is a possibility that we may have some potential cure for AIDS or cancer existing within the depths of a marine ecosystem, or a tropical rainforest.

Thus option value is the value of knowing that there are biological resources existing on this biosphere that may one day prove to be an effective option for something important in the future. Thus, the option value of biodiversity suggests that any species may prove to be a miracle species someday.The biodiversity is like precious gifts of nature presented to us. We should not commit the folly of losing these gifts even before unwrapping them.

The option value also includes the values, in terms of the option to visit areas where a variety of flora and fauna, or specifically some endemic, rare or endangered species exist.

Man and the Web of Life

The Biodiversity of an area influences every aspect of the lives of people who inhabit it. Their living space and their livelihoods depend on the type of ecosystem. Even people living in urban areas are dependent on the ecological services provided by the wilderness.

The quality of water we drink and use, the air we breathe, the soil on which our food grows are all influenced by a wide variety of living organisms both plants and animals and the ecosystem of which each species is linked with in nature.

While it is well known that plant life removes carbon dioxide and releases the oxygen we breathe, it is less obvious that fungi, small soil invertebrates and even microbes are essential for plants to grow.

That a natural forest maintains the water in the river after the monsoon, or that the absence of ants could destroy life on earth, are to be appreciated to understand how we are completely dependent on the living 'web of life' on earth.

The wilderness is an outcome of a long evolutionary process that has created an unimaginably large diversity of living species, their genetic differences and the various ecosystems on earth in which all living creatures live. This includes mankind as well. Think about this and we cannot but want to protect out earth's unique biodiversity. We are highly dependent on these living resources.

Source: Erach Bharucha, UGC Publication

G. **Ecological value** It refers to the services provided by ecosystems like prevention of soil erosion, prevention of floods, maintenance of soil fertility, cycling of nutrients, fixation of nitrogen, cycling of water, their role as carbon sinks, pollutant absorption and reduction of the threat of global warming etc.

Different categories of biodiversity value clearly indicate that ecosystem, species and genetic diversity all have enormous potential and a decline in biodiversity will lead to huge economic, ecological and socio-cultural losses.

4.5. THREATS TO BIODIVERSITY

Extinction or elimination of species is a natural process. Species have died out and have been replaced by others during evolution. However, the rate of loss of species in past has been a slow process. The process of extinction has become particularly fast in the recent years of human civilization. In this century, the human impact has been so severe that thousands of species and varieties are becoming extinct annually. One of the estimates by the noted ecologist, E.O. Wilson puts the figure of extinction at 10,000 species per year or 27 per day! According to a 2014 study by the World Wildlife Fund, the planet has lost 52% of its biodiversity since 1970. This startling figure raises an alarm regarding the serious threat to biodiversity. If the present trend continues we would lose 1/3rd to 2/3rd of our current biodiversity by the middle of twenty first century. Overexploitation of natural resources, deforestation, pollution, etc are among the major anthropogenic causes which lead to huge losses of biodiversity. The main threats to biodiversity are due to the following:

4.5.1. Loss of Habitat

Every living species live, feed and breed in a specific natural habitat. Destruction of natural habitat is the single largest cause of biodiversity loss. Overconsumption, overpopulation, land use change, deforestation, pollution (air pollution, water pollution, soil contamination) and global warming are the major factors responsible for habitat loss. Billions of hectares of forests and grasslands have been cleared over the past 10,000 years for conversion into agriculture lands, pastures, settlement areas or development projects. These natural forests and grasslands were the natural homes of thousands of species. All of these species have perished due to loss of their natural habitat. Severe damage has been caused to wetlands in the country. The unique rich biodiversity of the wetlands, estuaries and mangroves are under the most serious threat today due to shrinking areas of wetlands. Sometimes the loss of habitat is done by dividing a large tract of habitat into small and scattered patches, a phenomenon known as **habitat fragmentation**. With increased population, the habitats are fragmented into pieces by roads, fields, canals, power lines, towns etc. The isolated fragment of habitats restricts the potential of species for dispersal and colonization. There are many wild life species such as bears and large cats that require large territories to survive. They get badly threatened due to Habitat fragmentation as they breed only in the interiors of the forests. In addition, the habitat fragmentation also brings about microclimatic changes in light, temperature, wind etc.

With the current rate of loss of forest habitat, it is estimated that 20-25% of the global flora would be lost within a few years.

4.5.2 Poaching

Poaching is another cause of biodiversity loss. Illegal trade of wildlife products by killing prohibited endangered animals has resulted either in extinction or great reduction of wildlife. Despite international ban on trade in products from endangered species, smuggling of wildlife items like furs, hides, horns, tusks, live specimens and herbal products worth millions of dollars per year continues. The rich countries in Europe and North America and some affluent countries in Asia like Japan, Taiwan and Hong Kong are the major importers of the wild life products or wild life itself from the biodiversity-rich Asian and African countries. The trading of such wild life products is highly profit making for the poachers who just hunt these prohibited wild life and smuggle it. The worse part of the story is that for every live animal that actually gets into the market, about 50 additional animals are caught and killed.

4.5.3. Man-wildlife Conflicts

Sometimes we come across conflicting situations when wildlife starts causing immense damage and danger to man and under such conditions it becomes very difficult for the forest department to pacify the affected villagers and gain local support for wild-life conservation.

The root causes of these conflicts are dwindling habitats of tigers, elephants, rhinos and bears. Shrinking forest cover compels them to move outside the forest and attack the field or sometimes even humans. Human encroachment into the forest areas raises a conflict between man and the wildlife, perhaps because it is an issue of survival of both.

Some of the other factors responsible for biodiversity loss at global scale are:

4.5.4. Invasion

Invasion of non-native species is an important and often-overlooked cause of extinctions. The native species cannot compete with the fast growing invasive species and ultimately become extinct in the area.

4.5.5. Climate change

A changing global climate threatens species and ecosystems. The distribution of species (biogeography) is largely determined by climate, as is the distribution of ecosystems and plant vegetation zones (biomes). Climate change may simply shift these distributions but, for a number of reasons, plants and animals may not be able to adjust.

4.5.6. Pollution

Environmental pollution is yet another cause of extinction for many species of plants, animals and microbes. Toxic chemicals introduced in natural habitats and ecosystems may cause various forms of diseases and disturbances in the natural functioning of ecosystems and also become part of organisms after entering food chain.

4.5. Biodiversity Hotspots

A biodiversity hotspot is a region with a significant reservoir of biodiversity particularly of endemic species that is under threat from humans. The term hotspot was introduced in 1988 by Norman Myers. While hotspots are spread all over the world, the majority are forest areas and most are located in the tropics. To qualify as a biodiversity hotspot on Myers 2000 edition of the hotspot-map, a region must meet two strict criteria:

- It must contain at least 1,500 species (or 0.5 percent of the world's total) vascular plants as endemics, and
- It has to have lost at least 70% of its primary vegetation or natural habitat.

Three factors that usually determine hotspots

1. The number of total species (species richness)
2. The number of unique species (endemism)
3. The number of species at risk (threat of extinction).

At present there are 25 hotspots identified and recognised in various parts of the world. These areas although collectively constitutes only 1.4% of the land's geographic area but support at least 60% of the world's plant, bird, mammal, reptile, and amphibian species, with a very high share of endemic species.

There are at least 34 areas around the world which qualify under the definition of hotspot. In 2005 Conservation International (CI) published an updated list of proposed biodiversity hotspots. This list includes following areas in different parts of the world:

North and Central America

- California Floristic Province
- Madrean pine-oak woodlands
- Mesoamerica

The Caribbean

- Caribbean Islands

South America

- Atlantic Forest
- Cerrado

- Chilean Winter Rainfall-Valdivian Forests
- Tumbes-Chocó-Magdalena
- Tropical Andes

Europe

- Mediterranean Basin

Africa

- Cape Floristic Region
- Coastal Forests of Eastern Africa
- Eastern Afromontane
- Guinean Forests of West Africa
- Horn of Africa
- Madagascar and the Indian Ocean Islands
- Maputaland-Pondoland-Albany
- Succulent Karoo

Central Asia

- Mountains of Central Asia

South Asia

- Eastern Himalaya, Nepal
- Indo-Burma, India and Myanmar
- Western Ghats, India and Sri Lanka, Sri Lanka

South East Asia and Asia-Pacific

- East Melanesian Islands
- New Caledonia
- New Zealand
- Philippines
- Polynesia-Micronesia
- Southwest Australia
- Sundaland
- Wallacea

East Asia

- Japan
- Mountains of Southwest China

West Asia

- Caucasus
- Irano-Anatolian

Two regions that satisfy the hotspot criteria in India are described below.

The Western Ghats

The region: The Western Ghats are a chain of hills that run along the western edge of peninsular India. Due to their proximity to the ocean and through orographic effect, they receive very high rainfall. These regions have moist deciduous forest and rain forest. The region shows high species diversity as well as high levels of endemism. Nearly 77% of the amphibians and 62% of the reptile species found here are found nowhere else.

Biodiversity: There are over 6000 vascular plants belonging to over 2500 genera in this hotspot, of which over 3000 are endemic. Much of the world's spices such as black pepper and cardamom have their origins in the Western Ghats. The region also harbors over 450 bird species, about 140 mammalian species, 260 reptilian and 175 amphibian species. Over 60% of the reptiles and amphibians are completely endemic to this region. Remarkable as this diversity is, it is severely threatened today. The vegetation in this hotspot originally extended over 190,000 square kms. Today, it hass been reduced to just 43,000 sq. km.

The Eastern Himalayas

The region: The Eastern Himalayas is the region encompassing Bhutan, northeastern India, and southern, central, and eastern Nepal. The region is geologically young and shows high altitudinal variation. Some of the world's major river systems arise in the Himalayas, and their combined drainage basin is home to some 3 billion people (almost half of Earth's population) in 18 countries

Biodiversity: The Eastern Himalayan hotspot has nearly 163 globally threatened species including the One-horned Rhinoceros (Rhinoceros unicornis), the Wild Asian Water buffalo (Bubalus bubalis) and in all 45 mammals, 50 birds, 17 reptiles, 12 amphibians, 3 invertebrate and 36 plant species. The Relict Dragonfly (Epiophlebia laidlawi) is an endangered species found here with the only other species in the genus being found in Japan. The region is also home to the Himalayan Newt (Tylototriton verrucosus), the only salamander species found within Indian limits.

There are an estimated 10,000 species of plants in the Himalayas, of which one-third are endemic and found nowhere else in the world. Five families - Tetracentraceae, Hamamelidaceae, Circaesteraceae, Butomaceae and Stachyuraceae - are completely endemic to this region. A few threatened endemic bird species such as the Himalayan Quail, Cheer pheasant and Western tragopan are found here, alongwith some of Asia's largest and most endangered birds such as the Himalayan vulture and White-bellied heron.

The Himalayas are home to over 300 species of mammals, a dozen of which are endemic. Mammals like the Golden langur, The Himalayan tahr, the pygmy hog, Langurs, Asiatic wild dogs, sloth bears, Gaurs, Muntjac, Sambar, Snow leopard, Black bear, Blue sheep, Takin, the Gangetic dolphin, wild water buffalo, swamp deer call the Himalayan ranged their home. The only endemic genus in the hotspot is the Namadapha flying squirrel which is critically endangered and is described only from a single specimen from Namdapha National Park.

4.6 ENDANGERED SPECIES

The International Union for Conservation of Nature and Natural Resources (IUCN) is an international organisation working for biodiversity conservation. It publishes the **Red Data Book** which includes the list of endangered species of plants and animals. The ‘red data’ symbolizes the warning signal for that if not protected the endangered species are likely to become extinct in near future.

In India, nearly 450 plant species have been identified in the categories of endangered, threatened or rare. A few species of endangered reptiles, birds, mammals and plants are given below:

Reptiles: Gharial, green sea turtle, tortoise, python

Birds: Great Indian bustard, Peacock, Pelican, Great Indian Hornbill, Siberian White Crane, etc.

Carnivores: Indian wolf, red fox, Sloth bear, red panda, Mammals tiger, leopard, striped hyena, Indian lion, golden cat, desert cat, dugong

Primates: Hoolock gibbon, lion-tailed macaque, Nilgiri langur, Capped monkey, golden monkey, etc.

Plants: A large number of species of orchids, Rhododendrons, medicinal plants like *Rauvolfia serpentina*, the sandal wood tree *Santalum*, *Cycas beddonei* etc.

The Zoological Survey of India reported that Cheetah, Pink headed duck and mountain quail have already become extinct from India.

4.7. BIODIVERSITY CONSERVATION

In view of the tremendous threats to biodiversity, its conservation becomes very important. We have already lost a great treasure of biodiversity and the rate of its loss is alarming at present. Various agreements have been signed at international level to conserve the existing assets of biodiversity. Different conservation measures require to be adopted at local, national and global levels. International agencies, organisation or important agreements involved in conservation include:

- United Nations Convention on Biological Diversity (1992) and Cartagena Protocol on Biosafety

- o Convention on International Trade in Endangered Species (CITES)
- o Ramsar Convention (Wetlands)
- o Bonn Convention on Migratory Species;
- o World Heritage Convention (indirectly by protecting biodiversity habitats)
- o Regional Conventions such as the Apia Convention
- o Bilateral agreements such as the Japan-Australia Migratory Bird Agreement.

In India various acts and other legal measures have been formulated to assure the protection of Country's rich biodiversity.

Some non-government organizations working for biodiversity conservation

A. Bombay Natural History Society
B. Wildlife Preservation Society of India, Dehradun.
C. World Wide Fund for Nature India (WWF)
D. International Union for Conservation of Nature and Natural Resources(IUCN)
E. Green Peace

Laws Governing Biodiversity Conservation in India

A. The Madras Wild Elephant Preservation Act, 1873.
B. All India Elephant Preservation Act, 1879.
C. The Indian Fisheries Act, 1897.
D. Wild Birds and Wild Animals Protection Act, 1912.
E. The Indian Forest Act, 1927.
F. Bengal Rhinoceros Act, 1932.
G Haily National Park Act. 1936.
H. Bombay Wild, Animals and Wild Birds Protection Act, 1951.
I. Assam Rhinoceros Protection Act, 1954.
J. The Cruelty against Animals Act, 1960.
K. The Wildlife (Protection) Act, 1972.
L. The Forest (Conservation) Act, 1980.
M. Wildlife (Protection) Amendment Act; 1991.

4.7.1. Conservation Strategies

We need to adopt proper strategy to effectively conserve biodiversity. Some of the important points to be taken into consideration for this purpose include:

1. Unique and fragile ecosystems should be preserved.
2. All the economically important organisms should be identified and conserved.
3. All the varieties of food, forage and timber plants, live stock, animals and microbes should be conserved.
4. Critical habitats for each species should be identified and protected.
5. Sustainable utilisation of resources should be encouraged and ensured
6. International trade in wild life should be discouraged.
7. The poaching and hunting of wildlife should be prevented.
8. Environmental pollution should be reduced to minimum possible levels.
9. Reserves and protected areas should be developed as far as possible.
10. Public awareness should regarding biodiversity and its importance should be increased.
11. Environment protection laws should be strictly implemented.

4.7.2. Categories of Threatened Species

In order to undertake proper and effective conservative measures for protection of biodiversity, species of plants and animals are grouped in different categories based on the threat of extinction they face.

Extinct: A species is said to be extinct when it is not seen in the wild for 50 years at a stretch e.g. Dodo, passenger pigeon.

Endangered (E): A species is said to be endangered when its number has been reduced to a critical level or whose habitats, have been drastically reduced and if such a species is not protected and conserved, it is in immediate danger of extinction.

Vulnerable (V): A species is said to be in vulnerable category if its population is facing continuous decline due to overexploitation or habitat destruction. Such a species is still abundant, but under a serious threat of becoming endangered if causal factors are not checked.

Rare(R): A species which are not endangered or vulnerable at present, but are at a risk are categorized as rare species. These taxa are usually localized within restricted areas i.e. they are usually endemic. Sometimes they are thinly scattered over a more extensive area.

Threatened (T): Threatened is used in the conservation context for species which are in one of the categoriser Endangered, Vulnerable and Rare. Some species are marked as threatened where it is known that they are Endangered, Vulnerable or Rare, but there is known that they are Endangered, Vulnerable or Rare, but there is not enough information to say which of these three categories is appropriate.

Out of Danger (O): Species formerly included in one of the above categories, but which are now considered relatively secure because effective conservation measures have been taken or the previous threat to their survival has been removed.

Indeterminate (I): Species that are suspected of belonging to one of the first three categories, but for which insufficient information is currently available

4.7.3. Methods of Biodiversity Conservation

A number of measures are now being taken the world over to conserve biodiversity including plants and wildlife. There are two approaches of biodiversity conservation:

A. **In situ conservation** (within habitat): This is achieved by protection of wild flora and fauna in nature itself. e.g. Biosphere Reserves, National Parks, Sanctuaries, Reserve Forests etc.
B. **Ex situ conservation** (outside habitats): This is done by establishment of gene banks, seed banks, zoos, botanical gardens, culture collections etc.

4.7.3A. In-situ Conservation

It refers to the conservation of various species in their natural habitat or natural ecosystem. In the process, the natural surroundings or ecosystem is protected and maintained so that all the constituent species (known or unknown) are conserved and benefited. The factors which are detrimental to the existence of species concerned are eliminated by suitable mechanism.

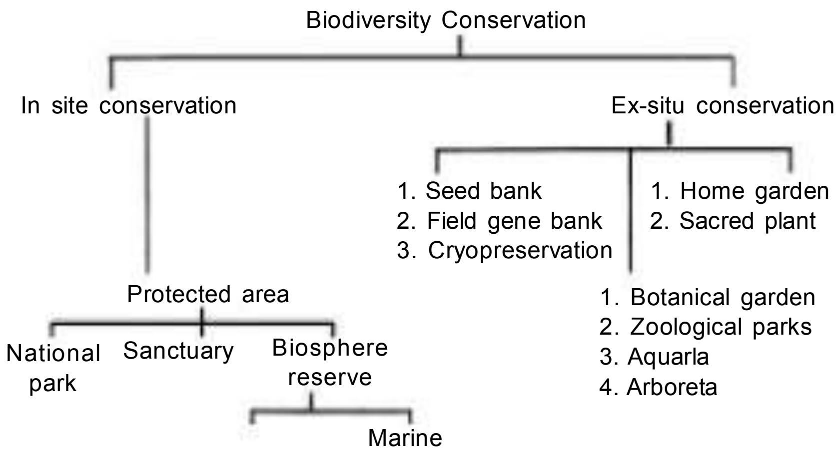
Protected areas have been set up all over the world with the specific aim of protecting and conserving plants and animals. There are various categories of protected areas such as biosphere reserve, national parks, wildlife sanctuaries, etc. There are 37,000 protected areas throughout the world.

A. Biosphere Reserves: They are the protected areas used to conserve some representative ecosystems as a whole for long-term in situ conservation. It is a special category of protected areas where human population also forms a part of the system. They comprises of large areas of usually more than 5000 sq.km. A biosphere reserves has 3 parts- core, buffer and transition zone.

1. Core zone is the inner zone; this is undisturbed and legally protected area.
2. Buffer zone lies between the core and transition zone. Some research and educational activities are permitted here.
3. Transition zone is the outermost part of biosphere reserves. Here cropping, forestry, recreation, fishery and other activities are allowed.

In India we have Nanda Devi (U.P.), Nokrek (Meghalaya), Manas (Assam), Sunderbans (West Bengal), Gulf of Mannar (Tamil Nadu), Nilgiri (Karnataka, Kerala, Tamil Nadu), Great Nicobars and Similipal (Orrisa) Biosphere Reserves.

Within the Biosphere reserves we may have one or more National Parks. For example, Nilgiri Biosphere Reserve has two National Parks viz. Bandipur and Nagarhole National Park.



B. National Park: It is an area dedicated for the conservation of Wildlife along with its environment. It is also meant for enjoyment through tourism but without impairing the environment. Grazing of domestic animals, all private rights and forestry activities are prohibited within a National Park. Each National Park usually aims at conservation specifically of some particular species of wildlife along with others.

C. Wildlife sanctuaries: They are also the protected areas where killing, hunting, shooting or capturing of wildlife is prohibited except under the control of highest authority. However, private ownership rights are permissible and forestry operations are also permitted to an extent that they do not affect the wildlife adversely.

For the protection and conservation of certain animals, there have been specific projects in our country e.g. Project Tiger, Gir Lion Project, Crocodile Breeding Project, Project Elephant, Snow Leopard Project

Important National Parks of India

India's first national park was established in 1936 as Hailey National Park, now known as Jim Corbett National Park, Uttarakhand. By 1970, India only had five national parks. In 1972, India enacted the Wildlife Protection Act. Further federal legislation strengthening protections for wildlife was introduced in the 1980s. As of now there are **105 national parks** encompassing an area of 40,500 km^2, comprising 1.23% of India's total surface area.

Below is a list of important national parks of India.

Name	State	Established	Area (in km^2)	Notability
Balphakram National Park	Meghalaya	2013	220	wild water buffalo, red panda, elephant and eight cat species, including the tiger and marbled cat
Bandhavgarh National Park	Madhya Pradesh	1968	446	highest known tiger population in India, white tiger, 1336 species of endemic plants
Bandipur National Park	Karnataka	1974	874.20	chital, gray langurs, Indian giant squirrel, gaur, leopard, sambar deer, honey buzzard, red-headed vulture
Bannerghatta National Park (Bannerghatta Biological Park)	Karnataka	1986	231.67	tiger, sloth bear, peacock, elephant, sambar deer, mouse deer
Bhitarkanika National Park	Odisha	1988	145	mangroves, saltwater crocodile, white crocodile, Indian python, black ibis, wild pigs, rhesus monkeys, chital

[Table Contd.

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Name	State	Established	Area (in km^2)	Notability
Blackbuck National Park, Velavadar	Gujarat	1976	34.08	hunting cheetahs, Blackbuck Lodge, the endangered Indian grey wolf, the nocturnal striped hyena, Indian fox, golden jackal, jungle cat and many small mammals like hare, gerbil, field mice, mongoose and hedgehog
Dachigam National Park	Jammu and Kashmir	1981	141	only area where Kashmir stag is found
Dinosaur Fossils National Park	Madhya Pradesh	2010	0.897	dinosaur fossils found
Gir Forest National Park	Gujarat	1965	258.71	Asiatic lion
Great Himalayan National Park	Himachal Pradesh,	1984	754.40	UNESCO World Heritage Site
Indravati National Park	Chhattisgarh	1981	1258.37	wild Asian buffalo, tiger reserve, hill mynas
Jaldapara National Park	West Bengal	2012	216	Indian rhinoceros
Jim Corbett National Park	Uttarakhand	1936	1318.5	
Kaziranga National Park	Assam	1905	471.71	Indian rhinoceros, UNESCO World Heritage Site
Keibul Lamjao National Park	Manipur	1977	40	only floating park in the world
Keoladeo National Park	Rajasthan	1981	28.73	UNESCO World Heritage Site
Kishtwar National Park	Jammu and Kashmir	1981	400	
Manas National Park	Assam	1990	500	UNESCO World Heritage Site
Mandla Plant Fossils National Park	Madhya Pradesh	1983	0.27	
Mount Harriet National Park	Andaman and Nicobar Islands	1987	46.62	important bird area as attributed by BirdLife International, new species frog named Rana Charles Darwini

[Table Contd.

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Name	State	Established	Area (in km^2)	Notability
Mukurthi National Park	Tamil Nadu	2001	78.46	Nilgiri tahr
Nanda Devi National Park	Uttarakhand	1982	630.33	UNESCO World Heritage Site
Nokrek National Park	Meghalaya	1986	47.48	UNESCO World Biosphere Reserve
Periyar	Kerala	1982	305	
Salim Ali National Park	Jammu and Kashmir	1992	9.07	
Sundarbans National Park	West Bengal	1984	1330.12	UNESCO World Heritage Site

Wildlife Sanctuaries in India

India has **515** wild life **sanctuaries** referred to as category IV protected areas. Among these, the 48 tiger reserves are governed by Project Tiger, and are of special significance in the conservation of the tiger. Many National Parks were initially wildlife sanctuaries. The conservative measures taken by the Indian Government for the conservation of Tigers was awarded by a 30% rise in the number of tigers in 2015.

Wildlife Sanctuaries of Jammu and Kashmir

S. No	Year of establishment	Name of WL Sanctuary	Area in km^2
1	NA	Karakoram Wildlife Sanctuary	1800
2	1987	Lachipora	800
3	1987	Overa-Aru	425
4	1988	Kanji Wildlife Sanctuary	250
5	1987	Gulmarg	186
6	1987	Hirpora Wildlife Sanctuary	341
7	1981	Surinsar-Mansar	39.58
8	1981	Nandini	33.72
9	2008	Achabal	NA
10	1987	Limber	26
11	NA	Tongri	20
12	1981	Ramnagar	12.9
13	NA	Hokarsar	10
14	1987	Baltal	3
15	1987	Changtang Wildlife Sanctuary	4000

Advantages of In-situ Conservation

i. It helps in the restoration of degraded ecosystems.

ii. Conservation is done without disturbing the natural habitats.

iii. There is minimum human interference

iv. It is not much complicated and is also less expensive

v. Interests of the locals or indibeous people are also protected

vi. Education and research can be done while conserving the wildlife.

4.7.3B Ex-situ Conservation

Ex-situ Conservation involves maintenance and breeding of endangered species under partially or fully controlled conditions in zoos, gardens, nurseries and laboratories. Ex situ conservation is adopted when it becomes impossible for an endangered species to survive in its natural habitat. The strategy of ex situ conservation involves:

o Identification of species to be conserved.

o The methods of ex situ conservation

Identification of species for ex situ conservation: Species are identified for conservation under this method on the basis of:

1. Vulnerability of the species to extinction.
2. Economic, ecological or aesthetic importance of the species.

The methods of ex-situ conservation: There are various methods or techniques to conserve endangered plants and animals away from their natural habitat. It is important to employ proper and suitable technique of ex situ conservation. The conservation technique for a specific endangered species is chosen on the basis of its suitability and necessity. These techniques are:

1. Long-term Captive Breeding: This method involves capture, maintenance and breeding of species in captivity on long term basis.
2. Short term propagation and release: Sometimes it becomes imperative to collect or capture and maintain the individuals of endangered species for a short time only. This is done when there is some temporary threats to the life of the species, disease out-break, food shortage etc.
3. Translocation: It involves the capture of individuals from a place where there is some sort of risk, problem or threat to them. Such individuals are translocated to some new more safer and secure natural habitat.
4. Use of Advanced Technology: Advances in technology and biotechnology can be used for conservation of endangered species of plants and animals. They include:

a. Nutrition, maintenance and health care of animals or plants in captivity
b. Artificial insemination
c. Embryo transfer technology
d. Cryopreservation of gametes and embryos.

Endangered plants may also be preserved through seed banks or germplasm banks. The term seedbank sometimes refers to a cryogenic laboratory facility in which the seeds of certain species can be preserved for up to a century or more without losing their fertility. A germplasm bank is a collection of live in the form of seeds or spores.In in-vitro storage cuttings of plants are kept under strict conditions in glass tubes and vessels. Endangered animal species are preserved using similar techniques. The genetic information needed in the future to reproduce endangered animal species can be preserved in gene banks, which consist of cryogenic facilities used to store living sperm, eggs, or embryos. The Zoological Society of San Diego has established a "Frozen zoo" to store such samples using modern cryopreservation techniques from more than 355 species, including mammals, reptiles, and birds.

Botanical Gardens and Zoos

They are the most conventional methods of ex situ conservation, all of which house whole, protected specimens for breeding and reintroduction into the wild when necessary and possible. These facilities provide not only housing and care for specimens of endangered species, but also have an educational value. They inform the public of the threatened status of endangered species and of those factors which cause the threat, with the hope of creating public interest in stopping and reversing those factors which jeopardize a species' survival in the first place. They are the most publicly visited ex situ conservation sites. The WZCS (World Zoo Conservation Strategy) estimates that the 1100 organized zoos in the world receive more than 600 million visitors annually.

Advantages of Ex-situ Conservation

i. It is highly useful where in-situ conservation is not possible or feasible.
ii. It is more reliable in certain cases where otherwise biodiversity loss becomes unavoidable.
iii. Plants, animals or their parts can be managed in better and more effective ways.

RECAPS AND PRACTICES

Walk and Talk

(Facts in brief)

- Biosphere consists of a vital life-support-system and supports a huge variety of life forms.
- Biodiversity is the result of 3.5 billion years of evolution.
  - o Until approximately 600 million years ago, all life consisted of archaea, bacteria, protozoans and similar single-celled organisms.
  - o The history of biodiversity during the Phanerozoic (the last 540 million years), starts with rapid growth during the Cambrian explosion—a period during which nearly every phylum of multicellular organisms first appeared.
- The term biological diversity was used first by wildlife scientist and conservationist Raymond F. Dasmann in the 1968 lay book A Different Kind of Country
- Lovejoy and other leading conservation scientists at the time in America advocated the use of the term "biological diversity". Until then the term "natural diversity" was common
- The term's contracted form biodiversity may have been coined by W.G. Rosen in 1985 while planning the 1986 National Forum on Biological Diversity organized by the National Research Council. It first appeared in a publication in 1988 when sociobiologist E. O. Wilson used it as the title of the proceedings of that forum.
- Non one exactly knows how many living species occur on the earth.
- No one knows the exact number of spp.
- Scientist, however, believe it to be somewhere between 10M to 80M.
- About 1.4M spp have so far been enlisted.
- only 2.5 to 12% of the total number of spp on the earth are described.(John C Ryan)
- There are estimated
  - o 1595225 known spp of plants
  - o 1168500 known of animals
  - o 35000 known spp of microorganisms/others
- Biodiversity can be considered at genetic (individuals differences within a species), species (number of species present) or ecosystem (variations among different ecosystems) levels.
- The number of different species and the relative abundance of each species in a biological community is called species diversity.

- The variety of genes or inheritable characteristics that are present in a population comprises its genetic diversity.
- Genetic diversity (races, varieties) within an interbreeding population increases the chances that some species will survive during changing environmental conditions or during the outbreak of disease.
- The variety of ecosystems that are present in the biosphere is called ecosystem diversity
- Tropics form the richest biodiversity region on the globe.
- Tropical rain forests, Temperate and sub tropical forests, the Boreal Coniferous forests of North, Wetlands, Mangroves, Coral Reef ecosystems are main store house of the world biodiversity.
- Tropical rain forests cover only 7% of land surface but contain 50% of all plant and animal species.
- **Mega biodiversity Regions**: Regions characterized by very high degree of biodiversity
- **Hotspots** : A biodiversity hotspot is a region with a high level of endemic species that is under threat from humans While hotspots are spread all over the world, the majority are forest areas and most are located in the
- **Endemism**: The presence of spp in restricted geographic areas.
- India has two Biodiversity Hotspots, viz. North Eastern Himalayas and Western Ghats
- India is one among world's megabiodiversity regions.
- India is home to 2,50000 plants. Out of them 45000(33%) are native to India
- India has 6% of the total flowering plants of the world.
- Natural extinction rate stands at 2.5spp/yr where as Enhanced/man made extinction rate may be 2500spp/yr.
- Pir Panjal is part of the western Himalayas which is one of the world's richest biodiversity regions
- Its home to thousands of very important spp of plants and animals many of whom are Endemic
- The United Nations supports a system of Biosphere Reserves and World Heritage sites.
- Currently, about seven percent of the world's land is set aside as some type of reserve.
- First national park -Yellowstone National Park –was established in– 1872.

Practice and Prepare

(Self Tests)

Choose the correct answer from the given choices in following question.

1. Variation between different populations or individuals of same species is
   a. Species diversity b. Genetic diversity
   c. Ecosystem diversity d. None of the above **Ans. b**
2. Which of the following is not a world heritage site
   a. Pariyar national park b. Nanda devi wildlife sanctuary
   c. Kaziranga national park d. Manas wildlife sanctuary **Ans. a**
3. Which of the following is not a world heritage site
   a. Pariyar national park b. Nanda devi wildlife sanctuary
   c. Kaziranga national park d. Manas wildlife sanctuary **Ans. a**
4. Which is not a use of biodiversity
   a. Medicinal b. Commercial
   c. Aesthetic d. Forensic **Ans. d**
5. Which of the following is Biodiversity Hotspot in India
   a. Western himalays b. Eastern himalays
   c. Ladakh d. Indoman Nicobar **Ans. b**
6. Which of the following is a cause of biodiversity loss
   a. Deforestation b. Pollution
   c. Invasion of non native species d. All of the above **Ans. d**
7. Asiatic lion is found in
   a. Kashmir Himalayas b. Sundarban forests
   c. Gir forests of Gujarat d. None of the above **Ans. c**
8. Bird 'Dodo' is
   a. Extinct b. Endangered
   c. Threatened d. Rare **Ans. a**
9. Which of these is not found in J&K
   a. Markhor b. Lion
   c. Bear d. Snow leopard **Ans. b**

10. Which plant species is found in J&K
    a. Pinus roxburgi b. Cedrus deodara
    c. Picea smithiana d. All of the above **Ans. d**
11. Which is not an organisation associated with biodiversity conservation
    a. WWF b. IUCN
    c. Red Ribbon Club d. None of the above **Ans. c**
12. Which does not involve an In situ conservation practice
    a. National park b. Wildlife sanctuary
    c. Gene bank d. Biosphere reserve **Ans. c**
13. Which of the following is not found in Pir Panjal Himalays
    a. Rhododendron b. Ibex
    c. Teak (*Tectona grandus*) d. Oak (ReeN) **Ans. c**
14. India is classified in .... biogeographic region
    a. 10 b. 16
    c. 11 d. 09 **Ans. a**
15. Presence of certain species restricted to a particular area is known as
    a. Extinction b. Endemism
    c. Hotspot d. None of the above **Ans. b**
16. India is............................
    a. Rich in biodiversity b. Poor in biodiversity
    c. Mildly rich in biodiversity d. Average in biodiversity **Ans. a**
17. Western Ghats are very rich in endemic species of
    a. Birds b. Lions
    c. Amphibians d. Turtles **Ans. c**
18. Dachigam National Park is famous for
    a. Elephant b. Birds
    c. Hangul or Kashmir stag d. Snow leopard **Ans. c**
19. Biodiversity is found to be highest in
    a. Polar region b. African countries
    c. Tropical region d. Oceans **Ans. c**
20. At present there are.......... National Parks in India
    a. 111 b. 115
    c. 116 d. 105 **Ans. d**

21. Project Elephant, Project Tiger and other such projects aim at
    a. Conserving biodiversity
    b. Regulating animal trade
    c. Minimising man-wildlife conflicts
    d. Taming wild animals
    Ans. a
22. Wildlife Protection Act was enacted in India in
    a. 1950
    b. 1972
    c. 1985
    d. 1995
    Ans. b
23. Red Data Book of IUCN is about
    a. Threatened species of animals and plants
    b. Criminal activities of smugglers
    c. confidential records of a country
    d. pollution and its impacts
    Ans. a
24. which is not an example of ex-situ conservation
    a. Gene bank
    b. Captive breeding
    c. Botanical garden
    d. Biosphere reserve
    Ans. d
25. Zoo or zoological garden involves
    a. Ex situ conservation
    b. In situ conservation
    c. Use of wild animals for commercial value
    d. None of the above
    Ans. a
26. Ramsar Sites refer to
    a. Forests with rich biodiversity
    b. Wetlands with good biodiversity
    c. Industrial sites where pollution becomes a problem
    d. An Iranian city
    Ans. b
27. Species diversity means
    a. Number of species belonging to same genus
    b. Number of species present in an area
    c. Number of individuals of a species present in an area
    d. Number of verities within a species
    Ans. b
28. Biodiversity does not include
    a. Micro-organisms
    b. Viruses
    c. Soil biota
    d. Water resources
    Ans. d

29. India is home to.............. species of plants

    a. 1,25000 b. 2,50000

    c. 3,00000 d. 45000 **Ans. b**

30. Out of 250000 plant species found in India, how much are endemic or native to the country

    a. 33% b. 23%

    c. 40% d. 65% **Ans. a**

Chapter 5

Environmental Pollution

What mankind must know is that human beings cannot live without Mother Earth, but the planet can live without humans.

Evo Morales

Objectives

We will learn in this unit about:

✓ Concept of pollution and pollutants

✓ Air pollution, causes, effects and control measures.

✓ Water pollution, causes, effects and control measures.

✓ Soil pollution, causes, effects and control measures.

✓ Solid waste: Municipal and industrial wastes

CHAPTER 5 ENVIRONMENTAL POLLUTION

Pollution- If You Don't Kill It, It Will Kill You

Frans Lanting

ABSTRACT

Overexploitation of various environmental components for the purposes of waste disposal is the most serious cause of widespread environmental degradation. Human activities generate different types of wastes which are ultimately dumped into his own surroundings. Toxic substances have been introduced into the air, waters and soils all around as a result of indiscriminate release of wastes in the open environment and the resultant condition is known as environmental pollution. Many of these pollutants are extremely harmful to life at the local level whereas many others have global scale disastrous impacts. Man and all other living organisms, however, need a pollution free healthy environment for survival and development. Humans, animals, plants, microorganisms and even property get badly affected by the pollutions in various ways. Pollutants enter ecosystem and disturb its functioning and stability. Even pollution has led to climatic changes in our environment. Global warming, ozone depletion, acid rains, etc are the symptomatic signs of environmental pollution.

INTRODUCTION

Environment is the complex of life support systems. It is required to be in a healthy and favourable state for normal and healthy life of all the living beings, including humans, livestock, plants, micro-organisms and the wildlife. The natural unpolluted environment has a specific composition. When this composition gets altered by addition of harmful substances, the environment is called polluted. Thus **pollution** may be defined as any undesirable change in the physical, chemical or biological characteristics of any component of the environment (i.e. air, water, soil, etc.). It can be natural or manmade and may prove detrimental or harmful for various forms of life or property.Pollution is in fact an outcome of the introduction of various **contaminants** into the natural environment that causes adverse changes in its natural features.

Any substance which causes pollution is called **pollutant**. A pollutant may be defined as any solid, liquid or gaseous present in such concentrations that may be harmful to the environment. A pollutant, thus, may be:

a. A chemical or geochemical substance such as dust, gases or vapours

b. A biotic component or its product such as pollens, volatile organic compounds (VOCs), etc.

c. A physical factors or energy such as heat, noise, etc.

Pollution can take the form of chemical substances such as gases, particulate matter or vapours or energy such as noise, heat or light. Though pollution can be caused by natural causes, it's mainly due to the by-products of man's action. Some of the important pollutants are summarised in various groups as below:

- **Gases—**Majority of the air pollutants are in gaseous form such as Carbon oxides, Nitrogen oxides, Sulphur oxides, halogens (Chlorine, Bromine and Iodine).
- **Metals—**There are number of metallic substances which cause serious environmental pollution. They include Lead, Zinc, Iron and Chromium, Cadmium, etc.
- **Industrial pollutants—**It refers to the harmful chemicals released from various industries. Benzene, ether, acetic acid etc., and cyanide compounds are some of the industrial pollutants.
- **Photochemical pollutants**—These are pollutants which react in presence of sunlight to form more dangerous products. They include Ozone, oxides of nitrogen, aldehydes, ethylene, photochemical smog and peroxy acetyl nitrate.
- **Agricultural pollutants—**Chemicals used in agricultural land, which cause soil and water pollution include pesticides, herbicides, fungicides and fertilizers.
- **Radiation pollutants—**Radioactive substances and radioactive fall-outs of the nuclear test.
- **Solid wastes—**such as municipal, domestic or other wastes generated during various anthropogenic activities

- **Noise**—unwanted soundthat causes inconvenience
- **Acid droplets**—such as sulphuric acid, nitric acid, etc.

For the purpose of study pollutants have been classified in various ways on the basis of different types of considerations such as their origin, nature, fate in the environment, toxicity, abundance, etc. Some major classifications, however, are asunder:

A. From the**ecological perspective**, pollutants can be classified as:

i. **Degradable or Non-persistent Pollutants**: These can be rapidly broken down by the natural processes. They are also known as **biodegradable** as the biological agents are involved in the process of their degradation. Examples include domestic sewage, discarded vegetables, etc.

ii. **Slowly Degradable or Persistent Pollutants**: Pollutants that remain in the environment for many years in an unchanged condition and take decades or longer to degrade. Examples include certain pesticides like DDT and most plastics.

iii. **Non-degradable Pollutants**: These pollutants cannot be degraded by natural processes. Once they are released into the environment they are difficult to eradicate and continue to accumulate. Examples are toxic elements like lead or mercury.

B. On the basis of the **form** in which they persist after their release into the environment, can be categorized under two types:

i. **Primary pollutants:** These include substances which are emitted directly from some identifiable sources. Examples include- Oxides of Sulphur, Carbon and Nitrogen released during combustion of fossil fuels in industries or automobiles.

ii. **Secondary pollutants.** The secondary pollutants are produced by the combination of primary pollutants in the environment. For exampleperoxyacetyle nitrate (PAN) and ozone (O3) which are formed due to photochemical reaction between Nitrogen oxides, Oxygen and hydrocarbons present in atmosphere. Both of them are toxic components of smog and cause various types of health problems.

Depending upon the component of environment that gets polluted, nature of pollutants, kind of damage caused by pollution or some other consideration there can be various types of pollution such as:

- Air pollution
- Water pollution
- Soil pollution
- Noise pollution
- Radiation pollution
- Thermal pollution
- Socio-cultural pollution
- Nuclear pollution, etc. etc.

DETAILS AND DISCUSSIONS

5.1. AIR POLLUTION

The air pollution is an unwanted atmospheric condition which can be definedas the presence of substances in the atmosphere in such concentrations which are harmful to man and his environment including other forms of life and valuable materials. Air pollution is the introduction of particulates, biological molecules, or other harmful materials into the Earth's atmosphere.

The atmosphere is a complex natural gaseous system that is essential to support life on the planet earth. A number of ingredients find their way into the natural atmospheric system and these are mostly gases, which can rapidly spread over wide areas. In addition to gaseous pollutants there may be vapours or particulate matter which can cause various types of harmful effects. They cause disease to humans, damage to other living organisms, natural resources, general environment or property.

According to the 2014 World Health Organisation (WHO) report, air pollution in 2012 caused the deaths of around 7 million people worldwide. Damages to agricultural productivity or monuments are also pronounced effects of air pollution.

5.1.1. Causes of Air Pollution

Air pollution may be natural or anthropogenic. Various sources of air pollution are burning of fossil fuels, industries, agricultural activities, wars, natural causes, emissions from vehicles etc.

A. Natural Causes

Gas emissions from active volcanoes, marsh gas, spores of fungi and pollens are the natural causes of air pollution. They can be summarised as below.

- **Dust** from natural sources.
- **Methane**, emitted from swampy lands and by the digestion of food by animals.
- **Smok**e and Carbon monoxide from wildfires.
- Volcanic activity which produces Sulphur oxides, Chlorine, and ash particulates.
- **Pollens** of various plant species during spring season
- Vegetation emits significant amounts of **VOCs** on warmer days. These VOCs react with primary anthropogenic pollutants—specifically, NO_x, SO_2, and anthropogenic organic carbon compounds — to produce a seasonal haze of secondary pollutants. Black gum, poplar, oak and willow are some examples of vegetation that can produce abundant VOCs.

B. Anthropogenic or Manmade Causes

Though there are natural causes of air pollution, the present scenario which poses a great threat to the entire humanity is mainly due to the disturbances in the environment created by man himself.

Pollution: The Historical Perspective

From historical viewpoint, the origin of pollution on the earth can be traced back to the times when man started using firewood as a means of cooking and heating. Hippocrates has mentioned air pollution in 400 BC. According to a 1983 article in the journal Science, "soot found on ceilings of prehistoric caves provides ample evidence of the high levels of pollution that was associated with inadequate ventilation. With the discovery and increasing use of coal, air pollution became more pronounced especially in urban areas. It was recognized as a problem 700 years ago in London in the form of smoke pollution, which prompted King Edward I to make the first antipollution law to restrict people from using coal for domestic heating in the year 1273. In the year 1300 another Act banning the use of coal was passed. Air pollution became a serious problem in London during the industrial revolution due to large scale use of coal in industries. The earliest recorded major disaster was the 'London Smog' that occurred in 1952 that resulted in more than 4000 deaths due to the accumulation of air pollutants over the city for five days.

i. **Burning of Fossil Fuels:** Burning of wood, charcoal and other fossil fuels cause air pollution by the release of Carbon dioxide (CO,), Carbon monoxide (CO) Sulphur dioxide, Nitrogen oxides, etc.

ii. **Emissions from Automobiles:** Vehicles are mainly responsible for more than 80% of the total air pollution in present era. The major pollutants released from automobiles, locomotives, aircraft etc., include CO, unburnt hydrocarbons and nitrogen oxide.

iii. **Industries:** Paper and pulp factories, petroleum refineries, fertilizer plants, and steel industries, thermal power plants are the main sources of air pollution. They add various harmful gases like CO, SO*ƒ* , NO, Hydrocarbons, etc., to the atmosphere. Textile factories release cotton dust into the air. Cities like Kanpur, Surat and Ahmedabad which are industrial hubs in our country experience this type of pollution. The pesticide and insecticide industries also pose serious threat to the environment. Food processing industries and tanneries emit offensive odours. Accidental release of poisonous gases from factories may also prove a serious source of pollution e.g. Bhopal Gas Tragedy in which methyl isocynate (MIC) gas leakage killed several people(we will read about it later in this chapter).

iv. **Agricultural Activities:** Spraying of insecticides and weedicides in the croplands also cause air pollution. These chemicals, when inhaled, create severe health problems to both animals and man.

v. **Wars:** Various forms of explosives used during wars have the potential to pollute the air by releasing poisonous gases. This greatly disturbs the ecology of the area. Nuclear explosions pollute air by radioactive rays. The effects of nuclear explosions on Hiroshima and Nagasaki are well-known examples.

5.1.2 Common Air Pollutants

Air pollutants are of two main types viz. gaseous and particulate. Oxides of Carbon, Nitrogen and Sulphur are gaseous pollutants. Particulate pollutants may be solid or liquid particles. Larger particles such as sand and water droplets settle down quickly whereas smaller dust particles remain suspended in air for a long time. These particulate materials are added into the atmosphere by the processes of blasting, drilling, crushing, grinding and mixing. Brief description of various types pollutants are being given here.

A. Gases

(i) **Carbon Dioxide:** Carbon dioxide (CO,) content of air has increased by 20% during last century. Its increase in the air may cause green house effect. This may melt the polar ice resulting in rise in level of oceans and flooding of coastal regions.

(ii) **Carbon Monoxide:** It is a very poisonous gas and is produced by incomplete combustion of fuel. On being inhaled it combines with haemoglobin and reduces its oxygen-carrying capacity. This leads to laziness, reduced vision and death.

(iii) **Oxides of Nitrogen:** These include NO and NO, which are released by automobiles and chemical industries as waste gases and also by burning of materials. These are harmful and lower the oxygen carrying capacity of blood.

(iv) **Oxides of Sulphur:** Sulphur dioxide (SO,) and Sulphur trioxide(SO*f*) are produced by burning of coal and petroleum. They are harmful to buildings, clothing, plants and animals. High concentration of SO, causes chlorosis (yellowing of leaves), plasmolysis (damage to mucous membrane) and metabolic inhibition. SO2 and SO3 react with water to form Sulphuric and sulphurous acids. These may precipitate as rain or snow producing acid rain or acid precipitation.

(v) **Photochemical Oxidants:** Nitrogen oxides in the presence of sunlight react with un-burnt hydrocarbons to form peroxyacyl nitrate (PAN), Ozone, aldehydes and some other complex organic compounds in the air.

(vi) **Hydrocarbons:** These are unburnt discharges from incomplete combustion of fuel in automobiles. These on reactions with nitrogen oxides form PAN which is highly toxic.

(vii) **Chlorofluorocarbons (CFCs):** These are gases which are released from air conditioners, refrigerators, aerosol sprays, etc. CFC's on being released into the air rises to stratosphere where they come in contact with other gases and damage the ozone layer. This allows harmful ultraviolet rays to reach the earth's surface where they can lead to skin cancer, disease to eye and even cause damage to plants.

(viii) **Ammonia (NH_3):** Ammonia is aa gas with a characteristic pungent odour. It is emitted from agricultural processes. Ammonia contributes significantly to the nutritional needs of terrestrial organisms by serving as a precursor to foodstuffs and fertilizers. Ammonia, either directly or indirectly, is also a building block for the synthesis of many pharmaceuticals. Although in wide use, ammonia is both caustic and hazardous. In the atmosphere, ammonia reacts with oxides of nitrogen and sulphur to form secondary particles.

ix) Fluorides: Rocks, soils and minerals containing fluorides release an extremely toxic gas called hydrogen fluoride on heating. This gas is highly injurious to cattle and other livestock.

(Singh, 2006).

x) Volatile Organic Compounds (VOCs): These are well-known outdoor air pollutants. They are categorized as either methane (CH_4) or non-methane (NMVOCs). Methane is an extremely efficient greenhouse gas which contributes to global warming. Other VOCs are also significant greenhouse gases because of their role in creating ozone and prolonging the life of methane in the atmosphere. The aromatic NMVOCs benzene, toluene and xylene are suspected carcinogens and may lead to leukemia with prolonged exposure. 1, 3-butadiene is another dangerous compound often associated with industrial use.

B. Particulate Matter

Industries and automobiles release fine solid and liquid particles into the air. Fly ash and soot from burning of coal, metal dust containing lead, chromium, nickel, cadmium, zinc and mercury from metallurgical processes; cotton dust from textile mills; and pesticides sprayed on crops are examples of particulate pollutants in the air. These are injurious to respiratory tract.

Table 5.1. various categories of pollutants. (E. Bharucha, UGC, 2004)

Term	Meaning	Examples
Aerosol	General term for particles suspended in air	Sprays from presurized 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	Cigarette smoke, smoke from burning garbage as fires
Fume	Generally means the same as smoke but often applied 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.	

C. Aerosols

Aerosols are chemicals released in the air in vapour form. These include fluorocarbon (carbon compound having fluorine) present in emissions from the Jet aeroplanes. Aerosols play role in ozone depletion.

D. Radioactive Substances

These are released by nuclear explosions and explosives. These are extremely harmful for health.

E. Odours

These are irritant or uncomfortable smells from various sources such as from garbage, sewage and certain industrial processes. These odours may cause allergies and psychological problems.

5.1.3 Indoor Air Pollution

It refers to the presence of harmful substances in air inside residential or other buildings. There are several pollutants which are found inside built houses and may cause affect the health of the residents. They are:

i. **Radon:** It is a radioactive gaseous element formed by the disintegration of radium. It can be emitted from building materials like bricks, concrete, tiles etc. which are derived from soil containing Radium. Radon is also present in groundwater and natural gas and is emitted indoors while using them. Radon and its other radioactive products are responsible for large number of lung cancer related deaths each year.

ii. **Oxides of Carbon, Nitrogen, and Sulphur:** Use of fuels like coal, dung-cakes, wood and kerosene in their kitchens. Complete combustion of fuel produces carbon dioxide which may not be toxic. However, incomplete combustion produces the toxic gas carbon monoxide. Coal contains varying amounts of Sulphur which on burning produces sulphur dioxide. Fossil fuel burning produces black soot. These pollutants i.e. CO, SO2, soot and many others like formaldehyde, benzo- (a) pyrene (BAP) are toxic and harmful for health.

iii. **Smoking:** Smoking not only affects the smoker but also those living in his surroundings. A person who is himself not a smoker but lives in an environment where someone smokes is known as a passive smoker. Smoking inside houses is a serious nuisance and equally harmful for non-smokers living there.

iv. **Use of sprays and chemicals:** Domestic use of odrous substances also sometimes causes indoor air pollution and may be harmful for the inhabitants.

5.1.4 Smog and Photochemical Smog (Smoke+Fog)

Smog is a type of air pollutant. The word "smog" was made in the early 20th century as a combination of the words smoke and fog to refer to smoky fog. **Smog** is caused by the burning of large amounts of coal and contains sootparticulates from smoke, sulfur dioxide and other components.

Another type of smog is a type of air pollution derived from vehicular emissions from internal combustion engines and industrial fumes that react in the atmosphere with sunlight to form secondary pollutants that also combine with the primary emissions to form **photochemical smog**. This noxious mixture of air pollutants can include the following:

- Aldehydes
- Nitrogen oxides, such as nitrogen dioxide
- Peroxyacyl nitrates
- Tropospheric ozone
- Volatile organic compounds

All of these harsh chemicals are usually highly reactive and oxidizing. Photochemical smog is therefore considered to be a problem of modern industrialization.

3.1.5 Air Pollution Scenario in India

The World health Organization (WHO) has rated Delhi the fourth most polluted city in the world. Our country has several pollution hotspots. The recent release from the Central Pollution Control Board (CPCB), states that Ahmedabad's air is most noxious flowed by Kanpur, Solapur and Lucknow with small particulate levels (PM10) 3-4 times the standard of 60 microgram per cubic meter (mg/m3). Such reports from time to time confirm the fact that Indian cities show high particulate pollution with 14 cities hitting critical levels. Nitrogen dioxide levels in most major cities are generally close to the acceptable annual standard of 60 mg/m3. However, sharp increases have been noticed in cities with heavy vehicular traffic and density as in Kolkata and Delhi. The CPCB indicates vehicles as one of the predominant sources of air pollution. Rapid urbanization of smaller cities especially those situated near the big commercial centers have an enormous increase in traffic load which contribute to the deteriorating air quality in a big way. The TajMahal being exposed to Sulphur dioxide and suspended particulate matter, had contracted 'marble cancer'. The suspended particulate matter (SPM) deposits blackened it. In the state of Jammu and Kashmir, pollution related problems are common in Jammu and Srinagar towns and some other industrial areas. Vehicular pollution is a common occurrence in all urban areas. Developmental and constructional activities even in rural and hilly areas create health problems for local inhabitants by polluting their environment.

3.1.6 Effects of Air Pollution

Air pollution is a serious environmental issue.It adversely affects human health, plant and animal life, biodiversity of an area, materials and monumental structures and even climatic regimes.

A. Effects on Human Health

About 90% of man's total daily intake of materials is contributed by air. An average human being breathes 22000 times a day and inhales about 16 kg of Oxygen. When polluted air is inhaled by humans it is likely to affect their health.

Respiratory problems: Continuous exposure to air pollutants (including cigarette smoke) adversely affect the natural defences in humans and can result in lung cancer, asthma, chronic bronchitis and emphysema (damage to air sacs leading to loss of lung elasticity and acute shortness of breath).

Suspended particulates can cause damage to lung tissues and diseases like asthma, bronchitis and cancer especially when they bring with them cancer causing or toxic pollutants attached on their surface.

Sulphur dioxide (SO_2) causes constriction of respiratory passage and can cause bronchitis like conditions. In the presence of suspended particulates, SO_2 can form acid sulphate particles, which can go deep into the lungs and affect them severely. Oxides of nitrogen especially NO, can irritate the lungs and cause conditions like chronic bronchitis and emphysema.

Carbon monoxide (CO) reaches lungs and combines with haemoglobin of blood to form **Damage to cardiovascular system**: Carboxyhaemoglobin. CO has affinity for haemoglobin 210 times more than oxygen. Haemoglobin is, therefore, unable to transport oxygen to various parts of the body. This causes suffocation. Long exposure to CO may cause dizziness, unconsciousness and even death.

Genetic disorders: Many other air pollutants like benzene (from unleaded petrol), formaldehyde and particulates like polychlorinated biphenyls (PCBs) toxic metals and dioxins (from burning of polythene) can cause mutations, reproductive problems or even cancer.

Cancer: Hydrocarbons and other pollutants act, as carcinogens and lead to different cancers.

Similarly Cotton dust leads to respiratory disorders e.g. bronchitis and asthma. Smoking of tobacco causes cancerous growth in lungs.

Skin disorders: Several pollutants present in air causes skin problems in humans. They also cause skin allergies.

Allergies: Several pollutants such as pollens, sprays or chemicals cause serious allergies among humans. Such allergens(allergy causing substances) may also cause serious respiratory and skin problems.

Others: Ozone (when present at ground level) causes dryness of mucous membranes, changes eye vision, causes headache, pulmonary congestion and oedema. It has also been reported to produce chromosomal aberrations.

B. Effects on Vegetation

Air pollutants entering through stomata (leaf pores through which gases diffuse) causes harmful effectson plants. It destroys chlorophyll and affects photosynthesis. Pollutants also erode waxy coating of the leaves called cuticle. Cuticle prevents excessive water loss and damage from diseases, pests, drought and frost. Damage to leaf structure causes necrosis (dead areas of leaf), chlorosis (loss or reduction of chlorophyll causing yellowing of leaf) or epinasty (downward curling of leaf), and abscission (dropping of leaves). Particulates deposited on leaves can form encrustations and plug the stomata. The damage can result in death of the plant. Some pollutant specific effects are as follows

a. SO, causes chlorosis and also results in the death of cells and tissues.

b. Fluorides and PAN damage leafy vegetables such as lettuce and spinach.

c. Oxides of nitrogen and fluorides reduce crop yield.

d. Smog bleaches and blaze foliage of important leafy plants.

e. Hydrocarbons cause premature yellowing, fall of leave and flower buds, discoloration and curling of sepals and petals.

f. Smoke and dust cover the leaf surface and reduce photosynthetic capacity of plants.

g. Ozone damages cereals, fruits, and cotton crop.

C. Effects on Aquatic Life

Air pollutants such as sulphuric acid and nitric acid coming down with rain water cause acidity in fresh water bodies. This affects aquatic life including fish, macrophytes and other forms of life present in water bodies.

D. Effects on Materials

Because of their corrosiveness, particulates can cause damage to exposed surfaces of materials and structures. Air pollutants break down exterior paint on cars and houses and other buildings. All around the world air pollutants have discoloured irreplaceable monuments, historic buildings and marble statues. Presence of SO_2 and moisture can accelerate corrosion of metallic surfaces. SO_2 can affect fabric, leather, paint, paper, marble and limestone. Ozone in the atmosphere can cause cracking of rubber. Oxides of nitrogen are also known to cause fading of cotton and rayon fibres.

E. Effects on Atmospheric Functioning and Climate

Atmospheric changes induced by pollution are contributing to global warming in a big way. Green house gases such as Carbon dioxide, CFCs, methane etc.are causing enhanced warming of earth's atmosphere. It is resulting in disturbances in climatic regimes besides many other negative effects. Ozone depleting substances are fast changing the compositional structure of upper atmosphere.

F. Aesthetic Loss

Dust and smoke spoils the beauty of nature. Especially the mountain environments, which serve as a great attraction for tourists, are being destroyed by air pollution. Foul odours emitted by industries, automobiles, dirty drains and garbage heaps in cities are a great nuisance.

5.1.1.5 Control of Air Pollution

Prevention or reduction of pollution is the most effective measure to control it. Minimizing the release of gases and particulates involve certain steps to be taken at source level. Following measures have been suggested to control air pollution.

- Siting of industries after proper Environmental Impact Assessment studies.
- Adopting suitable strategies for using raw material in industries such as using low sulphur coal in industries, removing sulphur from coal (by washing or with the help of bacteria) and removing NOx during the combustion process.
- Using methods to reduce the quantity or intensity of pollutants such as Some gases, which are more soluble in a particular liquid than air, for example, ammonia in water, can be separated by dissolving in it.
- Particles larger than 50 mm are separated in gravity settling tanks. Using cyclone collectors or electrostatic precipitators separates fine particles.
- The height of chimneys should be increased to the highest possible level to reduce pollution at the ground level.
- Pollution control laws should be enforced strictly.
- Trees should be planted on the roadside, riverbanks, parks and open places as they keep the environment fresh.
- Population growth, which is the main cause of pollution, should be checked.
- Nuclear explosions should be restricted.

Techniques to control air pollution

Certain useful techniques can be devised and applied to the gases and particulate emissions coming out from different industrial sources.

- **Adsorption:** Gaseous pollutants can be reduced by applying physical adsorption techniques. Outgoing gases can be adsorbed on porous materials such as silica gel or activated carbon and on some liquid absorbents.
- **Combustion:** Condensation and proper combustion of the effluent gases can also be applied to remove them before they exit into atmosphere.

  Use of Collectors: Particulates can be removed or reduced in quantity before their entry to the atmosphere from industrial units. Mechanical collectors such as dust cyclones, multicyclones, etc are used to collect and remove particles before they enter air. Electrostatic precipitator or electrostatic air cleaner is a particulate collection device that removes particles from a flowing gas (such as air), using the force of an induced electrostatic charge. Electrostatic precipitators are highly efficient filtration devices that minimally impede the flow of gases through the device, and can easily remove fine particulates such as dust and smoke from the air stream. Bag-houses are designed to handle heavy dust loads. In a wet scrubber, the polluted gas stream is brought into contact with the scrubbing liquid, by spraying it with the liquid, by forcing it through a pool of liquid, or by some other contact method, so as to remove the pollutants.

Bhopal Gas Tragedy

The Bhopal gas tragedy is considered the world's worst industrial disaster. It was a gas leak incident which occurred on the intervening night of 2–3 December, 1984 at the Union Carbide India Limited (UCIL) pesticide plant in Bhopal, Madhya Pradesh. The factory used to manufacture Carbanyl (Carbamate) pesticide using Methyl isocyanate (MIC). Due to accidental entry of water in the tank, the reaction mixture got overheated and exploded because its cooling system had failed. Other safety devices also did not work or were not in the working condition. It is believed that forty tons of MIC leaked into the adjoining atmosphere which might have contained 40 kg of phosgene as an impurity. MIC gas at lower concentrations affects lungs and eyes and causes irritation in the skin. Higher concentrations remove oxygen from the lungs and can cause death. The gas spread over large areas in the surroundings. About 2,50,000 persons got exposed to MIC. Though the estimates on the death toll vary, the official immediate death toll was 2,259. It was stated in a government affidavit in 2006 that the leak caused 5,58,125 injuries, including 38,478 temporary partial injuries and approximately 3,900 severely and permanently disabling injuries. Some other estimates say that 8,000 individuals died within two weeks, and another 8,000 or more have died since then due to gas-related diseases.

5.2 WATER POLLUTION

Water is the essential element that makes life possible on the earth. Water is an essential commodity for survival and day to day usage. We need water for drinking, cooking, bathing, washing, irrigation, and for industrial operations. Most of water for such uses comes from rivers, lakes or groundwater sources. Water has the property to dissolve many substances in it and therefore, can easily get polluted. Pollution of water can be caused by point sources or non-point sources. Water pollution can be defined as an alteration in the physical, chemical or biological characteristics of water making it unsuitable for designated use in its natural state.

5.2.1 Sources of Water Pollution

A. **Point sources of pollution:** When the source of water pollution can be easily identifiable it is said to be a **point source.** Thus point sources are the specific sites near some water body, which directly discharge effluents into them. Examples of main point sources are industries, power plants, underground coal mines, offshore oil wells etc.

B. **Non-point sources:** Where a source of pollution cannot be readily identified it is said to be **non-point source** of pollution. The discharge from **non-point sources** is not at any particular site, rather, these sources are scattered, which individually or collectively pollute water. Surface run-off from agricultural fields, overflowing small drains, rain water sweeping roads and fields, atmospheric deposition etc. are the non-point sources of water pollution.

5.2.2. Common Water Pollutants

There are several classes of pollutants which on mixing with water makes it unsuitable for a particular use.

A. **Pathogens:** These are **disease-causing agents** which include bacteria, viruses, protozoa and parasitic worms that enter water from domestic sewage and untreated human and animal wastes. Human wastes contain concentrated populations of certain bacterial groups such as *Escherichia coli* and *Streptococcus faecalis*. These bacteria are not harmful in lower concentrations but the increased number of them cause gastrointestinal diseases. Other potentially harmful bacteria from human wastes may also be present in smaller numbers. Other pathogenic organisms may also be present in different types of industrial, hospital or other kinds of wastes

B. **Oxygen depleting wastes:** These are organic wastes that can be decomposed microorganisms. Bacterial populations use up the oxygen present in water to degrade these wastes. In this process of degradation athe amount of oxygen present gets reduced which degrades water quality. The amount of oxygen required to break down a certain 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. Higher the amount of organic wastes in water higher would be its BOD. If too much organic matter is added to the water all the available oxygen is used up. This causes problems for fish and other forms of oxygen dependent aquatic life. In oxygen deficient situations anaerobic bacteria begin to break down the wastes. Their anaerobic respiration produces chemicals that have a foul odour and an unpleasant taste and can be harmful to human health.

C. Inorganic plant nutrients: These are water soluble nitrates and phosphates that cause excessive growth of algae and other aquatic plants. The excessive growth of algae and aquatic plants due to added nutrients is called eutrophication. They may interfere with the use of the water by clogging water intake pipes, changing the taste and odour of water and may cause accumulation of organic matter in the water bodies. As the organic matter decays, oxygen levels decrease and this again create problematic conditions for fish and other aquatic life-forms. The chemicals in fertilizers and pesticides pollute soil and water. While excess fertilizers cause eutrophication, pesticides cause bioaccumulation and biomagnification. Pesticides which 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 the herbivorous fish which are eaten by the carnivorous fish which are in turn eaten by the water birds. At each link in the food chain these chemicals which do not pass out of the body are accumulated and are increasingly concentrated resulting in biomagnification of these harmful substances. One of the effects of accumulation of high levels of pesticides such as DDT is that birds lay eggs with shells that are much thinner than normal. This results in the premature breaking of these eggs, killing the chicks inside. Birds of prey such as hawks, eagles and other fish eating birds are affected by such pollution. Although DDT has been banned in India for agricultural use and is to be used only for malaria eradication, it is still used in the fields as it is cheap.

D. 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 for drinking, harm fish and other aquatic life, reduce crop yields and accelerate corrosion of equipment that use this water.

E. Organic chemicals: Another cause of water pollution is a variety of organic chemicals which include oil, gasoline, plastics, pesticides, cleaning solvents, detergent and many other chemicals. These are harmful to aquatic life and human health. They get into the water directly from industrial activity either from improper handling of the chemicals in industries and more often from improper and illegal disposal of chemical wastes.

F. Sediments of suspended particles: These are insoluble particles of soil and other solids that become suspended in water. This occurs when soil is eroded from the land. High levels of soil particles suspended in water, interferes with the penetration of sunlight. This reduces the photosynthetic activity of aquatic plants and algae and disrupts the ecological balance of the aquatic bodies. When the flow of water in streams and rivers decreases the suspended particles settle down at the bottom as sediments. Excessive sediments that settle down destroys feeding and spawning grounds of fish, clogs and fills lakes, artificial reservoirs etc.

G. **Water soluble radioactive isotopes:** These can be concentrated in various tissues and organs as they pass through food chains and food webs after their entry into the water bodies. Ionizing radiation emitted by such isotopes can cause birth defects, cancer and genetic damage.

H. **Hot water:** Heated water released from power plants and industries that use large volumes of water for cooling purposes results in unusual rise of temperature in the local water bodies.

I. **Oil:** It gets washed into surface water in runoff from roads and parking lots and pollutes surface waters. Leakage from underground tanks is a source of groundwater pollution. Accidental oil spills from large transport tankers in the seas have also been causing significant environmental damage.

5.2.3. Types of Water Pollution

Water pollution can be subcategorised into following types

- Groundwater pollution
- Surface water pollution
- Marine water pollution and
- Thermal pollution

Ground-water Pollution

Ground water forms approximately 6.2% of the total water available on the planet earth. It is about 30 times more than the surface water i.e water in streams, lakes and estuaries. Ground water seems to be less prone to pollution as the soil mantle through which water passes helps to filter various contaminants due to its cation exchange capacity. However, there are a number of potential sources of ground water pollution such as septic tanks, industry (textile, chemical, and tanneries), deep well injection, mining etc. Ground water pollution with arsenic, fluoride and nitrate are posing serious health hazards. Groundwater flows are very slow and the contaminants are not effectively diluted and dispersed as compared to surface water. Ground water gets polluted due to:

- Leakage from underground storage tanks containing gasoline and other hazardous substances
- Leachate from landfills
- Poorly designed and inadequately maintained septic tanks
- Mining wastes

- 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

Severe cases of Arsenic poisoning from contaminated groundwater have been reported from West Bengal in what is known today as the worst case of groundwater pollution. As per a report published in the Down to Earth (*Vol. 11, No.22*), Arsenic poisoning was first noticed by K C Saha, former professor of dermatology at the School of Tropical Medicine, Kolkata when he began to receive patients with skin lesions that resembled the symptoms of leprosy which was in reality not leprosy.

Arsenicosis or arsenic toxicity develops after two to five years of exposure to arsenic contaminated drinking water. Initially the skin begins to darken which later leads to spotted melanosis. Arsenic poisoning brings with it other complications such as liver and spleen enlargement, cirrhosis of the liver, diabetes, goitre and skin cancers.

Surface-water Pollution

It refers to the contamination of terrestrial water bodies such as rivers, streams, lakes, ponds, etc. with harmful substances. The major sources of surface water pollution are:

A. **Sewage:** Pouring the drains and sewers in fresh water bodies causes water pollution. The problem is severe in towns and big cities.

B. **Industrial effluents:** Industrial wastes containing toxic chemicals, acids, alkalis, metallic salts, phenols, cyanides, ammonia, radioactive substances, etc. are a major source of water pollution. They may also cause thermal pollution of water.

C. **Synthetic detergents:** Synthetic detergents used in washing and cleaning produce foam and are known to pollute water.

D. **Agrochemicals:** Agrochemicals like fertilizers (containing nitrates and phosphates) and pesticides (insecticides, fungicides, herbicides etc.) washed by rain-water and surface run-off pollute water.

E. **Oil:** Oils getting mixed with from surface run off pollute surface water bodies.

F. **Waste heat:** Waste heat from industrial discharges increases the temperature of water bodies and affects distribution and survival of sensitive floral and faunal species.

5.2.4. Effects of Water Pollution

Following are some important and generalised effects of various types of water pollutants:

A. **Lowering of Dissolved Oxygen (DO)**: Organic matter which reaches water bodies, is decomposed by micro-organisms present in water. For this degradation, oxygen dissolved in water is consumed. Dissolved oxygen (DO) is the amount of oxygen dissolved in a given quantity of water at a particular temperature and atmospheric pressure. Amount of dissolved oxygen depends on aeration, photosynthetic activity in water, respiration of animals and plants and ambient temperature. The saturation value of DO varies from 8-15 mg/L. Lower DO may be harmful to animals especially fish population. Oxygen depletion (deoxygenation) helps in release of phosphates from bottom sediments and thus also causes eutrophication.

B. High Biological Oxygen Demand (BOD): The demand of DO increases with addition of biodegradable organic matter which is expressed as biological oxygen demand (BOD). BOD is defined as the amount of DO required to aerobically decompose biodegradable organic matter of a given volume of water calculated over a period of 5 days at 20°C. More BOD values of any water sample are associated with poor water quality.

C. Alteration in the physico-chemical characteristics of water: Addition of compounds containing nitrogen and phosphorus helps in the growth of algae and other plants which when die and decay consume oxygen of water. Under anaerobic conditions foul smelling gases are produced. Excess growth or decomposition of plant material will change the concentration of CO, which will further change pH of water. Changes in pH, oxygen and temperature will change many physico-chemical characteristics of water.

D. Presence of disease causing agents: Many wastewaters especially sewage contain many pathogenic and non-pathogenic micro-organisms and many viruses. Water borne diseases like cholera, dysentery, typhoid, jaundice etc. are spread by water contaminated with sewage.

E. Toxicity and diseases among humans: Pollutants such as heavy metals, pesticides, cyanides and many other organic and inorganic compounds are harmful to aquatic organisms. The non-biodegradable toxic compounds biomagnify in the food chain and cause toxic effects at various levels of food chain. Some of these substances like pesticides, methyl mercury etc. move into the bodies of organisms from the medium in which these organisms live. Substances like DDT are not water soluble and have affinity for body lipids. These substances tend to accumulate in the organisms' body. This process is called bioaccumulation. The concentration of these toxic substances builds up at successive levels in a food chain. This process is called **biomagnification**. Toxic substances polluting the water ultimately affect human health. Some heavy metals like lead, mercury and cadmium cause various types of diseases.

Some examples of such toxic pollutants which have caused large scale problems are as follows:

- Mercury dumped into water is transformed into water soluble methyl mercury by bacterial action. Methyl mercury accumulates in fish and then reaches humans and cause diseases. In 1953, people in Japan suffered from numbness of body parts, vision and hearing problems and abnormal mental behaviour. This disease called

Minamata disease occurred due to consumption of methyl mercury contaminated fish caught from Minamata bay in Japan. The disease claimed 50 lives and permanently paralysed over 700 persons.

- Pollution by heavy metal cadmium had caused the disease called Itai-itai in the people of Japan. The disease was caused by cadmium contaminated rice. The rice fields were irrigated with effluents of zinc smelters and drainage water from mines. In this disease bones, liver, kidney, lungs, pancreas and thyroid are affected.
- Arsenic pollution of ground water in Bangladesh and West Bengal is causing various types of abnormalities among humans using this water.
- Nitrate when present in excess in drinking water causes blue baby syndrome or methaemoglobinemia. The disease develops when a part of haemoglobin is converted into non-functional oxidized form. Nitrate in stomach partly gets changed into nitrites which can produce cancer-causing products in the stomach.
- Excess of fluoride in drinking water causes defects in teeth and bones called fluorosis. Pesticides in drinking water ultimately reach humans and are known to cause various health problems. DDT, aldrin, dieldrin etc. have therefore, been banned.
- Recently, in Andhra Pradesh, people suffered from various abnormalities due to consumption of endosulphan contaminated cashew nuts.

5.2.4A. Eutrophication (eu=enrichment; trophic=nutrients)

Eutrophication is the process of nutrient enrichment of a water body mainly as a result of pollution. It induces the explosive growth of plants and algae in the water body and changes its physico-chemical and biological characteristics. Human activities accelerate the rate at which nutrients enter aquatic ecosystems. Runoff from agriculture and development, pollution from septic systems and sewers and other related activities of man increase the flow of both inorganic nutrients and organic substances into aquatic ecosystems. The addition of these substances particularly phosphorus generally promotes excessive plant growth and causes a severe reduction in water quality. The source of this excess phosphate are detergents, industrial and domestic run-off and fertilizers. Enhanced growth of aquatic vegetation or phytoplankton and algal blooms disrupts normal functioning of the ecosystem. The water becomes cloudy or typically coloured. Eutrophication also decreases the aesthetic value of rivers, lakes, etc. Health problems can occur where eutrophic conditions interfere with drinking water treatment'. When algae die, they decompose and the nutrients contained in thier organic matter are converted into inorganic form by microorganisms. This decomposition process consumes oxygen, which reduces the concentration of dissolved oxygen. The depleted oxygen levels in the water body may lead to fish kills and other effects reducing overall bio-diversity.

5.2.4B. Biomagnification (bio=living; magnify=increase)

Biomagnification or Biological magnification or **bioamplification** refers to the process whereby certain substances such as pesticides or heavy metals (which may be toxic for living organisms) enter a food chain and move up with increasing concentrations at each higher level. Such substances work their way into the rivers, lakes or other ecosystems and become part of primary producers or primary consumers which are eaten by other living organisms such as fish, which in turn are eaten by large birds, animals or humans. The substances become concentrated in tissues or internal organs as they move up the food chain.

Biomagnification

Mercury is present in very small amounts in seawater, it is absorbed by algae (generally as methylmercury). It is efficiently absorbed, but very slowly excreted by organisms. Bioaccumulation and bioconcentration result in its build up in the adipose tissue of successive trophic levels such as zooplankton, small nekton or fish. Any organism which eats these fish is also bound to consume the higher level of mercury that the fish have accumulated. Thus the concentration of mercury goes on increasing in the tissues of organisms at higher trophic levels. DDT is thought to biomagnify and its biomagnification is one of the most significant reasons it was deemed harmful to the environment. DDT is stored in the fat of animals and takes many years to break down, and as the fat is consumed by predators, the amounts of DDT biomagnify. DDT is now a banned substance in many parts of the world.

Two other related terms are:

- **Bioaccumulation** occurs within a trophic level, and is the increase in concentration of a substance in certain tissues of organisms' bodies due to absorption from food and the environment.
- **Bio-concentration** is defined as occurring when uptake from the water is greater than excretion.

Thus, bioconcentration and bioaccumulation occur within an organism, and biomagnification occurs across trophic levels in a food chain.

Biodilution is also a process that occurs at all trophic levels in an aquatic environment; it is the opposite of biomagnification, thus a pollutant gets smaller in concentration as it progresses up a food web.

5.2.5. Control of Water Pollution

While the foremost necessity is prevention, setting up effluent treatment plants and treating waste through these can reduce the pollution load in the recipient waters. The following points may help in reducing water pollution particularly from non-point sources.

i. Judicious use of agrochemicals like pesticides and fertilizers which will reduce their surface run-off and leaching.

ii. Use of nitrogen fixing plants to supplement the use of fertilizers.

iii. Adopting integrated pest management to reduce reliance on pesticides.

iv. Preventing run-off of manure from croplands. Such run-off can be diverted to suitable basin for settlement. The nutrient rich water can be used as fertilizer in the fields.

v. Planting trees to reduce pollution by sediments and to prevent soil erosion.

For controlling water pollution from point sources, treatment of wastewaters is essential before it is discharged into nearby water bodies. Parameters which are considered for reduction in such water are-Total solids, biological oxygen demand (BOD), chemical oxygen demand (COD), nitrates and phosphates, oil and grease, toxic metals etc.

vi. Wastewaters should be properly treated by primary, secondary and tertiary treatments to reduce the BOD, COD levels up to the permissible levels for discharge. Advanced treatment for removal of nitrates and phosphates will prevent eutrophication in water bodies. Wastewater should also be disinfected before discharging to kill the disease-causing organisms like bacteria.

vii. Proper chlorination should be done to prevent the formation of chlorinated hydrocarbons or disinfection should be done by ozone or ultraviolet radiations.

5.2.6. Thermal Pollution

Thermal pollution can be defined as presence of waste heat in the water which can cause undesirable changes in the natural environment. It is usually caused by discharge of warm water into a river or other water body.

Substances that biomagnify

There are two main groups of substances that biomagnify.

- Novel organic substances are not easily degraded because organisms lack previous exposure and have thus not evolved specific detoxification and excretion mechanisms, as there has been no selection pressure from them. These substances are consequently known as "persistent organic pollutants" or POPs.
- Metals are not degradable because they are elements. Organisms, particularly those subject to naturally high levels of exposure to metals, have mechanisms to sequester and excrete metals. Problems arise when organisms are exposed to higher concentrations than usual, which they cannot excrete rapidly enough to prevent damage. Some persistent heavy metals are especially harmful to the organism's reproductive system. Examples include DDT, Hexachlorobenzene (HCB), PCBs, Toxaphene, Monomethylmercury, etc.

Causes of thermal pollution: Heat producing industries i.e., thermal power plants, nuclear power plants, refineries, steel mills etc. are the major sources of thermal pollution. These industries generally draw cold water from some nearby water-body, uses it for cooling purposes and return to the same water body, with temperature 10-16°C higher than the initial temperature. Power plants, for example, utilize only 1/3 of the energy provided by fossil fuels for their operations. Remaining 2/3 is generally lost in the form of heat to the water used for cooling. Besides them certain effeluents containing hot liquids when pourd into nearby waters also cause thermal pollution.

Effects of thermal pollution: The temperature changes disturb the ecological balance of the water body. Tropical marine animals are generally unable to withstand a temperature increase of 2°C to 3°C and most sponges, mollusks and crustaceans are eliminated at temperatures above 37 æ%C. The general effects of thermal pollution are:

a. The dissolved oxygen content of water is decreased as the solubility of oxygen in water is decreased at high temperature.

b. High temperature becomes a barrier for oxygen penetration into deep cold waters.

c. Toxicity of pesticides, detergents and chemicals in the effluents increases with increase in temperature.

d. The composition of flora and fauna changes because the species sensitive to increased temperature due to thermal shock will be replaced by temperature tolerant species.

e. Metabolic activities of aquatic organisms increase at high temperature and require more oxygen, whereas oxygen level falls under thermal pollution.

f. Discharge of heated water near the shores can disturb spawning and can even kill young fishes.

g. Fish migration is affected due to formation of various thermal zones.

Measures to control thermal pollution: 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 reuse as cooling water. There are several 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. A second 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. Hot water is sprayed over baffles. Cool air entering from sides takes away the heat and cools the water.

5.2.7. 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. The main sources of marine pollution are (i) rivers, which bring pollutants from their drainage basins, (ii) Catchment area i.e. coastline where human settlements in the form of hotels, industry, agricultural practices have been established, and (iii) oil drilling and shipment.

- The pollutants which rivers carry from their drainage basins are finally poured into the sea. These include sewage sludge, industrial effluents, synthetic detergents, agrochemicals, solid wastes, plastics, metals and waste heat released by industries as discussed earlier. In the sea the pollutants get diluted and the organic matter is further broken down as in river water. Still many pollutants specially the recalcitrant ones remain unchanged or are partially degraded causing marine pollution. These pollutants get biomagnified and affect fisheries and other marine life.
- 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 tonnes. Ship accidents and accidental spillages at sea therefore can be very damaging to the marine environment.
- Offshore oil exploration and extraction also pollute the seawater to a large extent.

Control of Marine Pollution

a. Toxic pollutants from industries and sewage treatment plants should not be discharged in coastal waters.
b. Run off from non-point sources should be prevented to reach coastal areas.
c. Sewer overflows should be prevented by having separate sewer and rain water pipes.
d. Dumping of toxic, hazardous wastes and sewage sludge should be banned.
e. Developmental activities on coastal areas should be minimized.
f. Oil and grease from service stations should be processed for reuse.
g. Oil ballast should not be dumped into sea.
h. Ecologically sensitive coastal areas should be protected by not allowing drilling.

5.3. SOIL POLLUTION

The upper or outermost layer of the earth crust is known as soil which is formed by weathering of rocks. The process of soil formation is so slow that the soil may be regarded as a non-renewable natural resource. Organic matter in the soil makes it suitable for living organisms particularly plants on which all other living organisms depend.

Like air and water soil also gets polluted and consequently its quality or productivity gets reduced. Dumping of various types of materials especially domestic and industrial wastes causes soil pollution.

5.3.1. Sources of Soil Pollution

There are several materials, which adversely affect physical, chemical and biological properties of the soil and thus reduce its productivity. These are of various types and originate from different sources

- Wastes from domestic and household usages.
- Chemicals present in industrial wastes.
- Pesticides and insecticides that are sprayed on crops. .
- Fertilizers and manures that are added to the soil to increase the crop yield

Domestic wastes include garbage, rubbish material like glass, plastics, metallic cans, paper, fibres, cloth rags, containers, paints, varnishes etc. Leachates from dumping sites and sewage tanks are harmful and toxic, which pollute the soil. Industrial wastes are the effluents discharged from chemical industries, paper and pulp mills, tanneries, textile mills, steel industries, distilleries, refineries, pesticides and fertilizer industries, pharmaceutical industries, food processing industries, cement industries, thermal and nuclear power plants, mining industries etc. Huge quantities of these wastes are dumped on soils, thus contaminating them. Pesticides are used to kill pests that damage crops. These pesticides ultimately reach the soil and persist there for a long time. Pesticides which are persistent in nature are chlorinated hydrocarbon insecticides e.g. DDT, HCH, eldrin, lindane, heptachlor, endosulfan etc. Residues of these pesticides in the soils have long term effects especially under the temperate conditions. Industrial wastes also contain some organic and inorganic compounds that are refractory and non-biodegradable. Industrial sludge may contain various salts, toxic substances, metals like mercury, lead, cadmium, arsenic etc. Agrochemicals released with the wastes of pesticide and fertilizer factories or during agricultural practices also reach the soil and pollute it. Soil also receives excreta from animals and humans. The sewage sludge contains many pathogenic organisms, bacteria, viruses and intestinal worms which cause pollution in the soil. The sources of radioactive substances in soil are explosion of radioactive devices, radioactive wastes discharged from industries and laboratories, aerial fall out etc. Isotopes of radium, uranium, thorium, strontium, iodine, caesium and of many other elements reach the soil and persist there for a long time and keep on emitting radiations.

5.3.2. Effect of Soil Pollutants

Chemicals and pesticides affect the physical and biological properties of soil by killing the soil microorganisms. Some pesticides are also absorbed by the plants and through them are transferred to other organisms and ultimately affect food chains and food webs. Excretory products of livestock and human beings used as manure also pollute the soil. Pathogens present in the wastes and excreta contaminate the soil and vegetable crops causing diseases in man and domesticated animals. The faulty sanitation and unhygienic practices of the people considerably add to the soil pollution phenomenon. General effects of soil pollution can be summarised as below:

- Various types of chemicals like acids, alkalis, pesticides, insecticides, weedicides, fungicides, heavy metals etc. in the industrial discharges affect soil fertility by causing changes in physical, chemical and biological properties.
- Some of the persistent toxic chemicals inhibit the non-target organisms of soil flora and fauna and reduce soil productivity. These chemicals accumulate in food chain and ultimately affect human health. Indiscriminate use of pesticides specially is a matter of concern. Sewage sludge has many types of pathogenic bacteria, viruses and intestinal worms which may cause various types of diseases.
- Decomposing organic matter in soil also produces toxic vapours.
- Radioactive fallout on vegetation is the source of radio-isotopes which enter the food chain through the grazing animals. Some of these radio isotopes replace essential elements in the body and cause abnormalities e.g. strontium-90 instead of calcium gets deposited in the bones and tissues and the bones become brittle and prone to fracture. Radioisotopes which get attached with the clay become a source of radiation pollution.
- Nitrogen and phosphorus from the fertilizers in soil reach nearby water bodies with agricultural run-off and cause eutrophication. Chemicals or their degradation products from soil may percolate and contaminate ground-water resources.
- Increase in the concentration of soluble salts is called **salination**. This adversely affects the quality and productivity of soil. It takes place in two ways
- Sewage and industrial effluents which pollute the soil ultimately affect human health.

5.3.3. Control of Soil Pollution

Various measure to control soil pollution are-

a. Adopting proper solid waste management systems
b. Treatment of industrial effluents before discharging them on the soil.
c. Recycling and reusing of materials like paper, glass and plastics instead of dumping them in the open lands.
d. Using biodegradable wastes for generation of bio gas

e. Microbial degradation of biodradable wastes.
f. Avoiding Use of chemical fertilizers and encouraging use of bio fertilizers and manures.
g. Adopting biological control of pests instead of Using synthetic pesticides.
h. Using cattle dung and agricultural wastes in biogas plants'
i. Plantation and afforestation

5.4. NOISE POLLUTION

Sound is a form of energy. It can propagate through a medium like air. Sound wave is a pressure perturbation in the medium through which sound travels. The pressure of travelling sound-energy alternately causes compression and rarefaction. The number of compressions and rarefactions of the molecules of the medium (say, air) per unit of time is described as frequency of that sound. It is expressed in Hertz (Hz) which is equal to the number of cycles per second. Noise is an unwanted sound that causes discomfort and psychological irritation to individuals. it 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. Intensity of Noise or sound is measured on a scale decibel scale or dB scale. It measures the loudness of sound in terms relative units of energy. The scale starts from 0dB which is considered as the threshoulhd of hearing. One can pleasantly hear a sound of certain units on dB scale beyond which it hurts or starts disturbing him. Our ears can hear ordinary conversation between 30-60 decibels. Modern conversation has a noise value of 60 decibels. A decibel value greater than 80 decibels causes noise pollution. Noise becomes troublesome above 140 decibels.

Table 5.2 Decibal levels of some common sounds

dB Level	Sound
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
140	Threshold of pain
150	Instantaneous rupture of membrane

5.4.1. Sources of Noise Pollution

There are different sources of noise pollution in our environment. Noise emanating from factories, vehicles, 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.

5.4.2. Effects of Noise Pollution

Effects on man's physical health

Noise pollution effects both health and behaviour. 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. Permanent hearing loss usually called noise induced permanent threshold shift (NIPTS) represents a loss of hearing ability from which there is no recovery. Chronic exposure to noise may cause noise-induced hearing loss Noise pollution can cause hypertension. High noise levels can contribute to cardiovascular problems.

Effects on man's mental health

Noise pollution also is a cause of annoyance. Noise causes emotional or psychological effects such as irritability, anxiety and stress. Lack of concentration work effeciency and mental fatigue are significant health effects of noise.

Effects on wildlife

Noise can have a detrimental effect on wild animals, increasing the risk of death by changing the delicate balance in predator or prey detection and avoidance, and interfering the use of the sounds in communication, especially in relation to reproduction and in navigation. Acoustic overexposure can lead to temporary or permanent loss of hearing in wild animals.

Table 5.3. Permitted noise level (dB)

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

An impact of noise on wild animal life is the reduction of usable habitat that noisy areas may cause. Noise also makes species communicate more loudly, which is called Lombard vocal response. Zebra finches become less faithful to their partners when exposed to traffic noise.

5.4.3. Control of Noise Pollution

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, reducing noise levels at the source is the best control method. In industries noise reduction can be done by using rigid sealed enclosures around machinery that produces high levels of noise. Regular and thorough maintenance of operating machinery helps in noise reduction. Noise levels at construction sites can be minimzed using superior machinery, proper construction planning and scheduling techniques.

Creation of temporary barriers to physically block the noise can help contribute to reducing noise pollution. The path of traffic noise can also be blocked by construction of vertical barriers alongside the highway.

Planting of trees around houses can also act as an 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 decrease indoor noise levels significantly. Sound levels drop significantly with increasing distance from the noise source.

Increasing the path length between the source and the recipient offers a passive means of noise control

Use of ear plugs and earmuffs can protect individuals effectively from excessive noise levels.

5.5. RADIATION POLLUTION

Radiations are the waves of energy that travels and spread all around in our environment. These radiations are useful as well harmful for us. Examples include visible light, radio waves, microwaves, infrared and ultraviolet lights, X-rays, and gamma-rays, etc. The differences between these various types of radiation consist in some physical properties such as energy, frequency, and wavelength. Radiation pollution refers to the increase in **the natural radiation levels in our surroundings due to human activities.** It is said that in today’s world about 20% of radiation we are exposed to is due to human activities. The human activities that may release radiation involve activities with radioactive materials such as mining, handling and processing of radioactive materials, handling and storage of radioactive waste, as well as the use of radioactive reactions to generate energy (nuclear power plants), along the use of radiation in medicine (e.g. X-Rays) and research. Microwaves, cell phones, radio transmitters, wireless devices, computers, and other common commodities of today's life are also the sources of various types of radiations. Radioactive radiations are however believed to be the most harmful radiations.

Radioactive substances are present in nature. They undergo natural radioactive decay in which unstable isotopes spontaneously give out fast moving particles, high energy radiations or both, at a fixed rate until a new stable isotope is formed. The isotopes release energy either in the form of gamma rays (high energy electromagnetic radiation) or ionization particles i.e. alpha particles and beta particles. The alpha particles are fast moving positively charged particles whereas beta particles are high speed negatively charged electrons. These ionization radiations have variable penetration power.

Alpha particles can be interrupted by a sheet of paper while beta particles can be blocked by a piece of wood or a few millimeters of aluminium sheet. The gamma rays can pass through paper and wood but can be stopped by concrete wall, lead slabs or water.

The Chernobyl disaster

The Chernobyl disaster was a catastrophic nuclear accident that occurred on 26th of April, 1986 at the Chernobyl Nuclear Power Plant in Ukraine (then USSR), which was under the direct jurisdiction of the central authorities of the Soviet Union. An explosion and fire released large quantities of radioactive particles into the atmosphere, which spread over much of the western USSR and Europe. The reactor which had been working continuously for 2 years was shut down on April 25, 1986 for intermediate repairs. Due to faulty operations of shutting down the plant, explosion occurred in the reactor at 01.23 hrs on April 26, 1986. Three seconds later another explosion occurred.

The explosion was so severe that the 1000 tonne steel concrete lid of the reactor 4 blew off. Fire started at the reactor due to combustion of graphite rods. The Chernobyl disaster was the worst nuclear power plant accident in history in terms of cost and casualties. Fuel and radioactive debris spewed out in a volcanic cloud of molten mass of the core and gases. The debris and gases drifted over most of the northern hemisphere. Poland, Denmark, Sweden and Norway were affected. During the accident itself, 31 people died, 239 people were hospitalized and long-term effects such as cancers are still being investigated. it was feared that some of the 5,76,000 people exposed to the radiations would suffer from cancer.

5.5.1. Sources of Radioactivity

Various sources of radioactivity can be grouped into two broad categories

i. **Natural sources**: Sources of natural radioactivity include cosmic rays from outer space, radioactive radon-222, soil, rocks, air, water and food, which contain one or more radioactive substances.

ii. **Anthropogenic sources**: These sources are nuclear power plants, nuclear accidents, X-rays, diagnostic kits, test laboratories etc. where radioactive substances are used.

5.5.2. Effects of Radiations

Genetic damage is caused by radiations, which induce mutations in the DNA, thereby affecting genes and chromosomes. The damage is often seen in the offsprings and may be transmitted up to several generations.

Somatic damage includes burns, miscarriages, eye cataract and cancer of bone, thyroid, breast, lungs and skin.

Many scientists are of the view that due to body's ability to repair some of the damages, the adverse effects of radiations are observed beyond a threshold level. However, the other group believes that even a small dose of radiations over a period of time may cause adverse effects. They believe that the permissible limits of ionising radiations should be further reduced.

Damage caused by different types of radiations depends on the penetration power and the presence of the source inside or outside the body. Alpha particles lack penetration power but they have more energy than beta. They will be, therefore, dangerous when they enter the body by inhalation or through food. Alpha particles cannot penetrate the skin to reach internal organs whereas beta particles can damage the internal organs. Greater threat is posed by radioisotopes with intermediate half-lives as they have long time to find entry inside the human body.

Radioisotopes enter the environment during mining of uranium. The radioactivity in the earth's crust enters the crops grown there and ultimately reaches in human beings. Radionuclides enter the water bodies or the groundwater coming in contact with the contaminated soil or rock. Radioactive Iodine (I131) accumulates in thyroid gland and causes cancer. Similarly, strontium-90 accumulates in the bones and causes leukemia or cancer of bone marrow.

5.5.3. Control of Radiation/Nuclear Pollution

a. Siting of nuclear power plants should be carefully done after studying long term and short term effects.

b. Proper disposal of wastes from laboratory involving the use of radioisotopes should be done.

c. Workers in nuclear plants should be provided with nuclear gadgets and safety measures against accidents.

d. Leakage of radioactive elements from nuclear reactors, laboratories, transport, careless handling and use of radioactive fuels should be checked.

e. Level of radiation pollution should be monitored regularly in risk areas.

f. Disposal of radioactive wastes should be done with special attention.

5.6. SOLID WASTE MANAGEMENT

Wastes are yet another aspect of environmental pollution. Modern way of life has brought with it many nuisances of varying nature. Waste generation is one among these side effects of the contemporary developmental activities. Higher standards of living of ever increasing population are resulting in an increase in the quantity and variety of waste generated. A solid waste generally refers to the domestic, municipal or industrial wastes other than the liquid effluents.

5.6.1. Types of Solid Wastes

Solid wastes are classified in several different ways based on their hazardousness, sources or some other consideration. A simple classification is:

- Municipal or urban wastes
- Industrial wastes
- Hospital wastes
- Hazardous wastes
- Non-hazardous wastes
- Biodegradable wastes
- Non-biodegradable wastes

Hazardous wastes: Many of these wastes may be hazardous to man or other biological systems. A waste is classified as a hazardous if it exhibits any of the four primary characteristics viz. toxicity, reactivity, ignitability and corrosivity. In addition to this waste products that are either infectious or radioactive are also classified as hazardous.

Toxic wastes: Wastes of the substances which are poisonous even in very small or trace amounts.

Some may have an acute or immediate effect on humans or animals causing death or serious illness. Others may have a chronic or long term effect slowly causing irreparable harm to exposed persons.

It is now realized that if waste generation continues indiscriminately then very soon it would be beyond rectification. Management of solid waste has, therefore, become very important in order to minimize the adverse effects of solid wastes. Solid waste (waste other than liquid or gaseous) can be classified as municipal, industrial, agricultural, medical, mining waste and sewage sludge.

5.6.2. Sources of Urban and Industrial Wastes

Municipal or Urban waste: this type of waste consists of medical waste from hospitals; municipal solid wastes from homes, offices, markets (commercial waste) small cottage units, and horticulture waste from parks, gardens, orchards etc.

- Waste from homes (Domestic waste) contains a variety of discarded materials like polyethylene bags, empty metal and aluminium cans, scrap metals, glass bottles, waste paper, diapers, cloth/rags, food waste etc.
- Waste from shops mainly consists of waste paper, packaging material, cans, bottles, polyethylene bags, peanut shells, eggshells, tea leaves etc.
- Biomedical waste include anatomical wastes, pathological wastes, infectious wastes etc.
- Construction/demolition waste includes debris and rubbles, wood, concrete etc.
- Horticulture waste and waste from slaughter houses include vegetable parts, residues and remains of slaughtered animals, respectively.

The urban solid waste materials that can be degraded by microorganisms are called biodegradable wastes. Examples of this type of waste are vegetable wastes, stale food, tea leaves, egg shells, peanut shells, dry leaves etc. Wastes that cannot be degraded by microorganisms are called non-biodegradable wastes. For example, polyethylene bags, scrap metal, glass bottles etc.

Industrial waste: Industrial waste consists of a large number of materials including factory rubbish, packaging material, organic wastes, acids, alkalis and metals etc. During some industrial processing large quantities of hazardous and toxic materials are also produced. The main sources of industrial wastes are chemical industries, metal and mineral processing industries. Radioactive wastes are generated by nuclear power plants. Thermal power plants produce fly ash in large quantities. Solid wastes from other types of industries include scrap metal, rubber, plastic, paper, glass, wood, oils, paints, asphalt, tars, dyes, scrap leather, ceramics, abrasives, slag, heavy metals, asbestos, batteries. In Europe and North America the environmental laws and safety laws are becoming more stringent due to which disposal of hazardous wastes is becoming a problem. Cost of disposal of such wastes is increasing there and these wastes are, therefore, being exported to developing countries which do not even have sufficient knowledge or techniques for their disposal.

5.6.3. Effects of Solid Wastes

- Municipal solid wastes heap up on the roads due to absence of proper disposal mechanism. People clean their own houses and litter their immediate surroundings. This produces foul smell and breeds various types of insects and infectious organisms besides spoiling the aesthetics of the site.
- Industrial solid wastes are sources of toxic metals and hazardous wastes, which may spread on land and can cause changes in physicochemical and biological characteristics thereby affecting productivity of soils.
- Toxic substances may leach or percolate to contaminate the ground water.

- In refuse mixing the hazardous wastes are mixed with garbage and other combustible waste. This makes segregation and disposal all the more difficult and risky. Various types of wastes like cans, pesticides, cleaning solvents, batteries (zinc, lead or mercury) radioactive materials, plastics are mixed up with paper, scraps and other non-toxic materials which could be recycled. Burning of some of these materials produce dioxins, furans and polychlorinated biphenyls, which have the potential to cause various types of ailments including cancer.

5.6.4. Management of Solid Waste

For waste management we stress on the three R's -Reduce, reuse and recycle before destruction and safe storage of wastes.

Reduction in use of raw materials: Reduction in the use of raw materials will correspondingly decrease the production of waste.

Reuse of waste materials: The refillable containers which are discarded after use can be reused. Villagers make casseroles and silos from waste paper and other waste materials. Making rubber rings from the discarded cycle tubes which are used by the newspaper vendors, instead of rubber bands, reduces the waste generation during manufacturing of rubber bands.

Recycling of materials: Recycling is the reprocessing of discarded materials into new useful products. Old aluminium cans and glass bottles are melted and recast into new cans and bottles.

The process of reducing, reusing and recycling saves money, energy, raw materials, land space and also reduces pollution. Recycling of paper will reduce cutting of trees for making fresh paper. Reuse of metals will reduce mining and smelting of ores for recovery of metals from ores and prevent pollution.

For discarded wastes which cannot be reused or recycled the following methods can be adopted:

(i) Sanitary landfill: In a sanitary landfill, garbage is spread out in thin layers, compacted and covered with clay or plastic foam. In the modern landfills the bottom is covered with an impermeable liner, usually several layers of clay, thick plastic and sand. The liner protects the ground water from being contaminated due to percolation of leachate. Leachate from bottom is pumped and sent for treatment. When landfill is full it is covered with clay, sand, gravel and top soil to prevent seepage of water. Several wells are drilled near the landfill site to monitor if any leakage is contaminating ground water. Methane produced by anaerobic decomposition may be collected and burnt to produce electricity or heat.

(ii) Composting: Due to shortage of space for landfill in bigger cities, the biodegradable yard waste is allowed to degrade or decompose in an oxygen rich medium. A good quality nutrient rich and environmental friendly manure is formed which improves the soil conditions and fertility.

(iii) Incineration: Incinerators are burning plants capable of burning a large amount of materials at high temperature. The initial cost is very high. During incineration high levels of dioxins, furans, lead and cadmium may be emitted with the fly ash.

For incineration of materials, it is better to remove materials containing heavy metals and plastic containing chlorine before burning. Prior removal of plastics will reduce emissions of dioxins and polychlorinated biphenyls (PCBs)

5.7. OZONE LAYER DEPLETION

Ozone is a form of oxygen with three atoms instead of two. It is produced naturally from the photo-dissociation of oxygen molecules in the atmosphere. The upper stratosphere consists of considerable amounts of ozone and is called as **ozone layer** or **ozonosphere**. About 90% of the planet's ozone is in the ozone layer. Though the ozone is present up to 60 kms, its highest density remains in the region between 25 to 50 kms above earth's surface. The total amount of ozone in a 'column' of air from the earth's surface upto an altitude of 50 km is the total column ozone. This is recorded in Dobson Units (DU), a measure of the thickness of the ozone layer by an equivalent layer of pure ozone gas at normal temperature and pressure at sea level. This means that 100 DU=1mm of pure ozone gas at normal temperature and pressure at sea level. Ozone is a poisonous gas and is regarded as a pollutant when present at ground level in the atmosphere. The Stratospheric ozone, however, is a naturally-occurring gas that filters the sun's ultraviolet (UV) radiations which are harmful for man and other life forms in many ways.

In the absence of pollutants the creation and breakdown of ozone are purely governed by natural forces and is balanced in the upper stratosphere. However the presence of certain pollutants accelerates the breakdown of ozone and thus disturbs the balanced processes of its formation and destruction. Though scientists were aware of the fluctuations in the ozone concentrations, it was only in 1985 that the large scale destruction of the ozone was observed in the Antarctic atmosphere. This thinning of ozone concentration is also named as Ozone Hole. A reduced or thinned ozone layer allows more radiations to reach the Earth's surface. These radiations are harmful to man and other living organisms and cause serious implications for mankind.

5.7.1. Causes of Ozone Layer Depletion

There are certain chemical pollutants which cause the depletion of Ozone. It is caused by the release of chlorofluorocarbons (CFCs), hydrofluorocarbons (HCFCs), and other ozone-depleting substances (ODS), which were used widely as refrigerants, insulating foams, and solvents. When CFCs and HCFCs reach the stratosphere, the ultraviolet radiation from the sun causes them to break apart and release chlorine atoms which react with ozone, starting chemical cycles of ozone destruction that deplete the ozone layer. One chlorine atom can break apart more than 100,000 ozone molecules.

Other chemicals that damage the ozone layer include methyl bromide (used as a pesticide), halons (used in fire extinguishers), and methyl chloroform (used as a solvent in industrial processes for essential applications). As methyl bromide and halons are broken apart, they release bromine atoms, which are 60 times more destructive to ozone molecules than chlorine atoms.

While volcanoes and oceans release large amounts of chlorine, the chlorine from these sources is easily dissolved in water and washes out of the atmosphere in rain. In contrast, CFCs are not broken down in the lower atmosphere and do not dissolve in water. The chlorine in these human-made molecules does reach the stratosphere. Measurements show that the increase in stratospheric chlorine since 1985 matches the amount released from CFCs and other ozone-depleting substances produced and released by human activities.

5.7.2. Effects of Ozone Layer Depletion

A. **On human health:** Sunburn, cataract, aging of the skin and skin cancer are caused by increased exposure to ultra-violet radiations. It weakens the immune system by suppressing the resistance of the whole body to certain infections like measles, chicken pox and other viral diseases.

B. **On food production:** Ultra violet radiations affect the ability of plants to capture light energy during the process of photosynthesis.

C. **On materials**: Increased UV radiations damage paints and fabrics, causing them to fade faster than usual.

5.7.3. Measures to Control Ozone Depletion

In 1987, the Montreal Protocol was signed and the signatory nations committed themselves to a reduction in the use of CFCs and other ozone-depleting substances. Since then, the treaty has been amended multiple times to accelerate the phase out of CFCs, HCFCs, and other ozone depleting substances. Today, over 190 countries have ratified the treaty. For over a decade the production of CFCs has been banned, with limited exceptions for essential uses. Provided that we stop producing ozone-depleting substances, ozone will be created through natural processes that should return the ozone layer to normal levels by about 2050.

5.8. ACID RAIN

Acid rain is an outcome of air pollution. Oxides of sulphur and nitrogen originating from industrial operations and fossil fuel combustion are the major sources of acid forming gases.

When fossil fuels such as coal, oil and natural gas are burned, chemicals like sulphur dioxide and nitrogen oxides are produced. Hydrogen chloride emission forms hydrochloric acid. These chemicals react with water and other chemicals in the air to form sulphuric acid, nitric acid and other harmful pollutants like sulphates 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. Rain water is turned acidic when its pH falls below 5.6. In fact clean or natural rain water has a pH of 5.6 at 20°C because of formation of carbonic acid due to dissolution of CO2 in water. Generally sulfuric acid forms a major fraction of acid rain, followed by nitric acid and a very small fraction of other acids.

Acid deposition: In the absence of rain, dry deposition of acid may occur. Acid forming gases like oxides of sulphur and nitrogen and acid aerosols get deposited on the surface of water bodies, vegetation, soil and other materials. On moist surfaces or in liquids these acid forming gases can dissolve and form acids similar to that formed in acid rain. If the oxidizers are present on the liquid surfaces then these gases undergo oxidation to form acids.

5.8.2. Effects of Acid Rain

Acid rain causes a number of harmful effects which are visible in the aquatic or terrestrial systems or on materials.

- It causes deterioration of buildings especially made of marble e.g. monuments like TajMahal. Crystals of calcium and magnesium sulphate are formed as a result of corrosion caused by acid rain.
- It damages stone statues. Priceless stone statues in Greece and Italy have been partially dissolved by acid rain.
- It damages metals and car finishes.
- Aquatic life especially fish are badly affected by lake acidification.
- Aquatic animals suffer from toxicity of metals such as aluminium, mercury, manganese, zinc and lead which leak from the surrounding rocks due to acid rain.
- It results in reproductive failure, and killing of fish.
- Many lakes in the world like those of Sweden, Norway, and Canada have become fishless due to acid rain.
- It damages foliage and weakens trees. 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.
- It makes trees more susceptible to stresses like cold temperature, drought, etc. Many insects and fungi are more tolerant to acidic conditions and hence they can attack the susceptible trees and cause diseases.

- It dissolves and washes away nutrients in the soil which are needed by plants.
- 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.

5.8.2. Control of Acid Rain

Acid rain can be controlled by reducing emissions of pollutant gases from various sources. Emission of SO_2 and NO_2 from industries and power plants should be reduced by using pollution control equipments.

5.9. GLOBAL WARMING OR CLIMATE CHANGE

Troposphere, the lowermost layer of the atmosphere, traps heat by a natural process due to the presence of certain gases. This effect is called Green House Effect as it is similar to the warming effect observed in the horticultural green house made of glass. The amount of heat trapped in the atmosphere depends mostly on the concentrations of heat trapping or green house gases and the length of time they stay in the atmosphere. Heat trapped by green house gases in the atmosphere keeps the planet warm enough to allow us and other species to exist. Naturally occurring amounts of greenhouse gases have a mean warming effect of about 33 °C (59 °F). Without the Earth's atmosphere, the Earth's average temperature would be well below the freezing temperature of water i.e it would have been -88°C. The average global temperature is 15°C. The two predominant green house gases are water vapours, which are controlled by hydrological cycle, and carbon dioxide, which is controlled mostly by the global carbon cycle. While the levels

Climate models

A climate model is a computerized representation of the five components of the climate system: Atmosphere, hydrosphere, cryosphere, land surface, and biosphere. Such models are based on scientific disciplines such as fluid dynamics, thermodynamics as well as physical processes such as radiative transfer. The models take into account various components, such as local air movement, temperature, clouds, and other atmospheric properties; ocean temperature, salt content, and circulation; ice cover on land and sea; the transfer of heat and moisture from soil and vegetation to the atmosphere; chemical and biological processes; solar variability and others. Models are also used to help investigate the causes of recent climate change by comparing the observed changes to those that the models project from various natural and human-derived causes. Although these models do not unambiguously attribute the warming that occurred from approximately 1910 to 1945 to either natural variation or human effects, they do indicate that the warming since 1970 is dominated by man-made greenhouse gas emissions. Not all effects of global warming are accurately predicted by the climate models used by the IPCC. Observed Arctic shrinkage has been faster than that predicted. Precipitation increased proportional to atmospheric humidity, and hence significantly faster than global climate models predict. Since 1990, sea level has also risen considerably faster than models predicted it would.

(Courtesy: Wikipedia and UNEP)

of water vapour in the troposphere have relatively remained constant, the levels of carbon dioxide have increased. The phenomenon that worries the environmental scientists is that due to anthropogenic activities there is an increase in the concentration of the greenhouse gases in the air that absorb infra-red light containing heat and results in the re-radiation of even more of the outgoing thermal infra-red energy, thereby increasing the average surface temperature beyond 15°C. The phenomenon is referred to as the enhanced green house effect to distinguish its effect from the one that has been operating naturally for millennia. **Global warming** is the term used to describe a gradual increase in the average temperature of the Earth's atmosphere and its oceans. This is an ongoing change that is believed to permanently change the Earth's climate. Climate scientists looking at the data and facts agree the planet is warming. They believe that average temperature of the Earth has risen between 0.4 and 0.8 °C over the past 100 years.

5.9.1. Causes of Global Warming

The increased volumes of carbon dioxide and other greenhouse gases released by the burning of fossil fuels, land clearing, agriculture, and other human activities, are believed to be the primary sources of the global warming that has occurred over the past 50 years. Scientists from the Intergovernmental Panel on Climate carrying out global warming research have recently predicted that average global temperatures could increase between 1.4 and 5.8 °C by the year 2100. In its fifth assessment in 2014 the Intergovernmental Panel on Climate Change (IPCC) reported that scientists believe that most of global warming is caused by increasing concentrations of greenhouse gases and other human (anthropogenic) activities. The major green house gases are carbon dioxide, ozone, methane, nitrous oxide, chlorofluorocarbons (CFCs) and water vapours.

Carbon dioxide

It contributes about 55% to global warming from green house gases produced by human activity. Industrial countries account for about 76% of annual emissions. The main sources are fossil fuel burning (67%) and deforestation, other forms of land clearing and burning (33%). CO_2 stays in the atmosphere for about 500 years. CO_2 concentration in the atmosphere was 355 ppm in 1990 that is increasing at a rate of 1.5 ppm every year

Chlorofluorocarbons (CFCs)

These are believed to be responsible for 24% of the human contribution to greenhouse gases. They also deplete ozone in the stratosphere. The main sources of CFCs include leaking air conditioners and refrigerators, evaporation of industrial solvents, production of plastic foams, aerosols, propellants etc. CFCs take 10-15 years to reach the stratosphere and generally trap 1500 to 7000 times more heat per molecule than CO2 while they are in the troposphere. Atmospheric concentration of CFC is 0.00225 ppm that is increasing at a rate of 0.5% annually.

Methane (CH_4)

It accounts for 18% of the increased greenhouse gases. Methane is produced when bacteria break down dead organic matter in moist places that lack oxygen such as swamps, natural wetlands, paddy fields, landfills and digestive tracts of cattle, sheep and termites. Production and use of oil and natural gas and incomplete burning of organic material are also significant sources of methane. Methane stays in the atmosphere for 7-10 years. Each methane molecule traps about 25 times as much heat as a CO2 molecule. Atmospheric concentration of methane is 1.675 ppm and it is increasing at a rate of 1% annually.

Nitrous Oxide (N_2O)

It is responsible for 6% of the human input of green house gases. Besides trapping heat in the troposphere it also depletes ozone in the stratosphere. It is released from nylon products, from burning of biomass and nitrogen rich fuels (especially coal) and from the break down of nitrogen fertilizers in soil, livestock wastes and nitrate contaminated ground water. Its life span in the troposphere is 140-190 years and it traps about 230 times as much heat per molecule as CO_2. The atmospheric concentration of N2O is 0.3 ppm and is increasing at a rate of 0.2% annually.

5.9.2. Effects of Global Warming

Future climate change and associated impacts will be different from region to region around the globe. The effects of an increase in global temperature include

- Rise in sea levels due to melting of snow and ice and because water above 3.98 °C expands as it warms. One meter rise in sea level will inundate low lying areas of cities like Shanghai, Cairo, Bangkok, Sydney, Hamburg and Venice as well as agricultural lowlands and deltas in Egypt, Bangladesh, India, China and will affect rice productivity. This will also disturb many commercially important spawning grounds, and would probably increase the frequency of storm damage to lagoons, estuaries and coral reefs. In India, the Lakshadweep Islands with a maximum height of 4 meters above the level may be vulnerable. Life of millions of people will be affected in the deltas of the Ganges, the Nile, the Mekong, the Yangtze and the Mississippi rivers due to sea level rise.
- Change in the amount and pattern of precipitation, as well as a probable expansion of subtropical deserts.
- Warming is expected to be strongest in the Arctic, with the continuing retreat of glaciers, permafrost and sea ice.
- Other likely effects of the warming include more frequent extreme weather events including heat waves, droughts, heavy rainfall, and heavy snowfall, ocean acidification; and species extinctions due to shifting temperature regimes.

- Effects significant to humans include the threat to food security from decreasing crop yields and the loss of habitat from inundation. The global warming will lead to changes in the rainfall pattern in many areas, thereby affecting the distribution of vector-borne diseases like malaria, filariasis, elephantiasis etc. Areas which are presently free from diseases like malaria,schistosomiasis etc. may become the breeding grounds for the vectors of such diseases. The areas likely to be affected in this manner are Ethiopia, Kenya and Indonesia. Warmer temperature and more water stagnation would favour the breeding of mosquitoes, snails and some insects, which are the vectors of such diseases. Higher temperature and humidity will increase/ aggravate respiratory and skin diseases.
- Effects on Agriculture: There are different views regarding the effect of global warming on agriculture. It may show positive or negative effects on various types of crops in different regions of the world. Tropical and subtropical regions will be more affected since the average temperature in these regions is already on the higher side. Even a rise of 2°C may be quite harmful to crops. Soil moisture will decrease and evapo-transpiration will increase, which may drastically affect wheat and maize production. Increase in temperature and humidity will increase pest growth like the growth of vectors for various diseases. Pests will adapt to such changes better than the crops. To cope up with the changing situation drought resistant, heat resistant and pest resistant varieties of crops have to be developed.

5.9.3. Measures to Check Global Warming

Possible responses to global warming include mitigation by emissions reduction, adaptation to its effects, building systems resilient to its effects, and possible future climate engineering. Most countries are parties to the United Nations Framework Convention on Climate Change (UNFCCC), whose ultimate objective is to prevent dangerous anthropogenic climate change. The UNFCCC have adopted a range of policies designed to reduce greenhouse gas emissions and to assist in adaptation to global warming. Parties to the UNFCCC have agreed that deep cuts in emissions are required and that future global warming should be limited to below 2.0 °C (3.6 °F) relative to the pre-industrial level.

Mitigation of climate change is actions to reduce greenhouse gas (GHG) emissions, or enhance the capacity of carbon sinks to absorb GHGs from the atmosphere. There is a large potential for future reductions in emissions by a combination of activities, including: energy conservation and increased energy efficiency; the use of low-carbon energy technologies, such as renewable energy, nuclear energy, and carbon capture and storage and enhancing carbon sinks through, for example, reforestation and preventing deforestation.

To slow down enhanced global warming the following steps will be important:

- Cut down the current rate of use of CFCs and fossil fuel.
- Use energy more efficiently.
- Shift to renewable energy resources.

- Increase Nuclear Power Plants for electricity production.
- Shift from coal to natural gas.
- Trap and use methane as a fuel.
- Reduce beef production.
- Adopt sustainable agriculture.
- Stabilize population growth.
- Efficiently remove CO_2 from smoke stacks.
- Plant more trees.
- Remove atmospheric CO_2 by utilizing photosynthetic algae.

RECAPS AND PRACTICES

Walk and Talk

(Facts in brief)

- Environmental pollution is one among the serious environmental problems facing the humanity
- One molecules of CFC is capable of destroying 1 lakh molecules of O*f*
- CFC molecules remain unbroken for a century after their release in the atmosphere.
- Overall reduction in 0*f* concentrations is believed to be 8% till now.
- International agreement at Montreal (Montreal Protocol) in 1907 called for a freeze on use of CFCs.
- IPCC (intergovernmental panel on climate change) is involved, in collaboration of the specialists from all over the world to discus climatic changes, their effects and mitigation.
- Rio Earth Summit was held at Rio de Janerio in 1992
- Under Koyto Protocol (1997) rich industrial countries agreed to reduce their green house gas(GHG) emissions by an average of 5.2% by 2010.
- Infrared radiations are involved in warming of earth's atmosphere.
- Higher BOD in a water body indicates its pollution.
- Gulf war of 1991 caused large scale marine pollution particularly of Persian Gulf water.
- London smog incident occurred in 1952 and led to the death toll of 4000. It was reducing in its chemical nature.
- Photo-chemical smog is oxidising in nature and it was observed in Los Angeles, USA.
- A pollutant entering any component of environment may remain in that component (such as air, water or soil) or may travel to other components and/or living systems.
- During day time, the sun warms the air near earth's surface. When this heated air rises and expands over other areas it also carries with it pollutant and dilutes them.
- When a cold air gets trapped under a warm mass of air, it does not rise, expends and thus pollutants remains in it in higher concentrations in a local area. It is called **thermal inversion**.
- Some plant species show obvious effects of certain pollutants and they can be used for bio monitoring of pollution in an area. Such plants are known as indicator plants.
- Typhoid, cholera, Hepatitis, etc. are some of the common diseases caused by water pollutants in rural and urban areas.

- Global warming is an outcome of air pollution.
- Methane (CH_4) and water vapours are very affective greenhouse gases with global warming potential higher than that of CO_2.
- CO_2, due to its higher concentrations in the atmosphere, is responsible for fifty percent(50%)of global warming.
- Methane gas is responsible for 19% and water vapours for 2% of global warming.
- Radioactive pollution causes long term genetic disorders in human beings.
- Indoor Air pollution is a serious problem in rural areas. People regularly inhale CO, SO_4, formaldehyde, benzene á pyrene (BAP) and black soot.
- Carbon monoxide binds about 200 times faster than oxygen to haemoglobin. It causes death due to reduced capability of haemoglobin to carry Oxygen
- Fluorides in air cause chlorosis and necrosis in plants.
- Fluorides in water cause teeth and bones problem in humans.
- Green Muffler scheme refers to grow plants along roadsides to control noise pollution.
- DDT stands for Dichloro-Diphenyle-Trichloroethane.
- PCB stands for Polychlorinated biphenyls.
- Warmer water has less oxygen. Thermal pollution, thus, causes deoygenation of water bodies.
- 'Ballest water' is the water filled in empty tankers after oil is removed/unloaded. When this Ballest water is thrown in sea it also contains residual oil and pollutes sea water.
- Sometimes soil pollution is described as negtive and positive soil pollution. When useful soil components are removed or eroded it is called negative soil pollution and when some harmful substances are added to soil it is called positive soil pollution.
- Chlorinated hydrocarbons include DDT, DDE, Chlordane, Aldrin, Dieldrin, Endrin, BHC, Heptachalor, etc.

Practice and Prepare

(Self Tests)

1. Arsenic (As) is....

   a. A groundwater pollutant b. Surface water pollutant

   c. Not a pollutant d. Air pollutant **Ans. a**

2. Electrostatic precipitator is used to control

   a. Water pollution. b. Land pollution.

   c. Noise pollution. d. Air pollution. **Ans. d**

3. Treatment of sewage helps to control
   a. Water pollution b. Air pollution
   c. Radiation. d. Thermal pollution **Ans. a**

4. Intensity of noise is measured in
   a. Pitch of sound b. dB
   c. Joules d. Hertz(HZ) **Ans. b**

5. Ozone thickness is expressed in
   a. Cmx^8 (cubic cm) b. Cm^2/ m^2
   c. Dobson unit d. None of the above **Ans. c**

6. Which of the following may be present in Photochemical smog
   a. Aldehyde b. Ozone
   c. PAN d. All of the above **Ans. d**

7. Average amount of Ozone in stratosphere (at 0p C & 1 atm pressure)
   a. 300 DU b. 400DU
   c. 700DU d. 200DU **Ans. a**

8. Which of the following may be the effect of air pollution on vegetation
   a. Necrosis b. Ripening of fruit
   c. Epinasty d. Deforestation **Ans. a**

9. Which among the following is not an air pollutant
   a. CO_2 b. CO
   c. CH_4 d. DDT **Ans. d**

10. Ozone (O_3) is
    a. Protective cover in upper atmosphere
    b. A pollutant near earth's surface
    c. Neither (a) nor (b)
    d. Both (a) and (b) **Ans. d**

11. Sulphur dioxide (SO_2) is
    a. A primary pollutant b. Secondary pollutant
    c. Not a pollutant d. All of the above **Ans. a**

12. Lead (Pb) is
    a. Not a pollutant b. A pollutant
    c. A micronutrient d. None of the above **Ans. b**

13. Which poisonous gas released at Union Carbide Factroy at Bhopal in 1984
    a. MIC   b. NO_2
    c. CO   d. DDT

Ans. a. MIC (MethyleIsoCyante)

14. PAN (Peroxyacetyle nitrate) is
    a. A primary pollutant   b. Secondary pollutant
    c. Combination of pollutants   d. Not a pollutant   **Ans. b**

15. which among the following is not a greenhouse gas (GHG)
    a. CO_2 b. CH_4
    c. Pb   d. Water vapours   **Ans. c**

16. CFCs are responsible for .... of total global warming effect
    a. 10%   b. 4.5%
    c. 20%   d. 60%   **Ans. c**

17. Oxygen deficiency in blood due CO inhalation is called
    a. Hypoxia   b. Hyperoxia
    c. Deoxygenation   d. Oxygenation   **Ans. a**

18. Presence of weak acids in rain is known as
    a. Acidification of rain   b. Acidification of soil
    c. Acidity   d. Acid rain   **Ans. d**

19. CFCs causes
    a. Global warming   b. Ozone depletion
    c. None of the above   d. Both a. And b.   **Ans. d**

20. Bag filters are used to control
    a. Gaseous pollutant   b. Particulate pollutants
    c. Hydrocarbons   d. Water vapours   **Ans. b**

Chapter 6

Socio-environmental Issues

Man is a complex being: he makes deserts bloom and lakes die.

Gil Stern

OBJECTIVES

We will discuss in this chapter about the following:

- ✓ Human population growth and environment
- ✓ Environmental education-goals, objectives and need for public awareness
- ✓ Role of mass media and environmental organizations
- ✓ Environmental movements in India
- ✓ Concepts of eco mark and eco-friendly products

CHAPTER 6 SOCIO-ENVIRONMENTAL ISSUES

Healthy citizens are the greatest asset any country can have

Winston S. Churchill

ABSTRACT

Human individuals are the main asset of the society. Every society needs a sound manpower to progress in the world. Scientific and technological advancement has enabled man to conquer the rest of the world and use it for his welfare. But due to huge increase in human population on the earth it is becoming too difficult to get ample food, water and other resources required to live a healthy life. We need to keep human population within limits for a better life.

Disaster is a catastrophic situation that leads to sudden disruption of normal life of a society, causing damage to life and property to such an extent that normal social and economic values available are inadequate to restore normalcy after a disaster. In such a situation extra-ordinary emergency interventions are required to save and preserve lives and the environment.

Humanity is faced with serious environmental problems. Awareness about what is happening in environmental domains is very important if we intend to improve the situation. Environmental education aims at improving the quality of environment by making people understand the gravity of the problem and thus involving them in environmental protection.

INTRODUCTION AND DISCUSSION

6.1. HUMAN POPULATION

Humans are the most advanced creature on the earth. Man has conquered rest of the world and uses it for his welfare. Human populations are present almost on every habitable part of the earth. Human society has progressed scientifically to the greatest extent and has learnt to use various types of natural resources present on the planet. Population of mankind is increasing day by day due to better longevity, good resource utilization and better health care systems. Increase in population is also accompanied by certain problems for human society. Population is increasing at very high rates but the resources are limited. Availability of land, food, water and basic facilities for huge population is becoming a serious issue. Health related problems are also becoming unmanageable. Increasing population also uses huge amounts of energy and generates enormous wastes which are causing environmental problems including pollution and waste disposal issues.

6.1.1 Population Growth

Population refers to a group of individuals of the same species inhabiting an area. Some of the characteristics or a population are nasality (birth rate), mortality (death rate), sex ratio, age distribution, growth rates, and special distribution.

6.1.2. Characteristics of Population

Natality refers to the number of individuals added to the population through reproduction. In human populations, natality is usually described in terms of the birth rate, the number of individuals born per one thousand individuals in the population per year.

Mortality is the number of deaths per year per one thousand individuals in the population.

Population Density is population size in relation to some unit of space and time. It can be measured as:

$$D = N/at$$

Where D is population density, n = number of individuals, a = area and t = time.

Age Distribution: It refers to the number of individuals of different age groups in a population. There are three ecological ages as:

- Pre reproductive(0-14yrs)
- Reproductive(15-45)
- Post reproductive(above 45 yrs)

Age structure of population of a nation can be represented by age pyramids, based upon people belonging to different age classes like pre-reproductive (0-14 years), reproductive (15-44 years) and post reproductive (45 years and above). In these pyramids base indicates pre-reproductive, middle reproductive and top post-reproductive stages. We get three types of age pyramids:

1. **Pyramid-shapedfigure** (Broader at base and narrower upwards): Here the very young population is more, making a broad base and old people are less. This type indicates growing population. Examples: India, Bangladesh, Ethiopia, Nigeria etc.
2. **Bell-shaped figure** (equal size at base and middle and narrow at top): It shows people of almost equal number in pre reproductive and reproductive age group. So in the next 10 years, the people entering into reproductive age group is not going to change much and such age-pyramids indicate stable populations. Examples: France, USA and Canada.
3. **Urn-shaped figure** (Narrow at base, broader at top): Here number of individuals in young pre-reproductive class is smaller than the middle reproductive age class. In the next 10 years the number in reproductive age class will thus become less than before resulting in a decline of population growth. Examples: Germany, Italy, Hungary, Sweden and Japan.

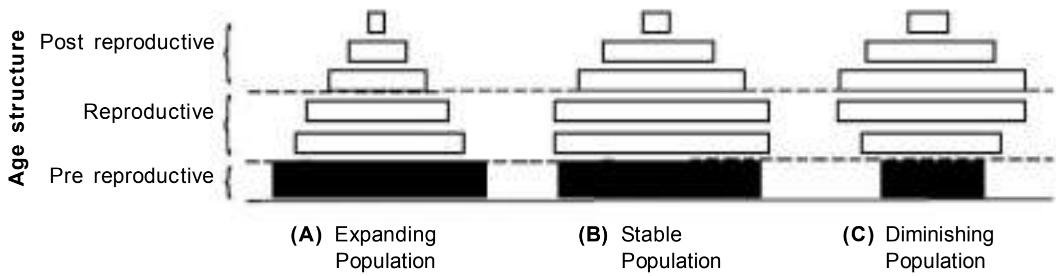

Fig. 6.1. Age structure (Singh, 2006)

Biotic Potential: It is the maximum reproductive power of a population. The constant percent growth rate of a population under optimum environmental conditions thus represents its biotic potential or reproductive potential.

Sex ratio: It refers to the number of males relative to the number of females in the population.

Life expectancy: It is the average age that a newborn infant is expected to attain in a given country. In India the life expectancy is 66.2 years. In Japan and Sweden, life expectancy is quite higher.

Zero population growth: When population is not growing and the number of births equals the number of deaths, it is said to exhibit **zero population growth.**

Population Growth Curves: it is a graphic representation of growth trends in a population. There are two types of growth curves identified by the ecologists.

S-shaped growth curve: When a species is introduced into a new habitat, the population grows exponentially until the individuals become numerous. The further increase in their number is checked by the environmental resistance factors that the population growth declines until zero population growth is reached. (Such curves are also called **sigmoid curves**.

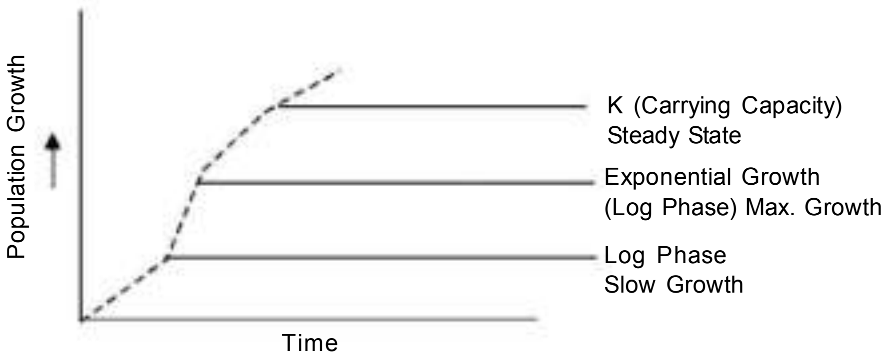

Fig. 6.2. S-shaped growth curve

J-shaped growth curve: The population increases whenever there is an increase in birth rate over death rate.

The factors of environmental resistance do not check population growth or stabilize the growth (zero growth not established) then a J-shaped curve is obtained.

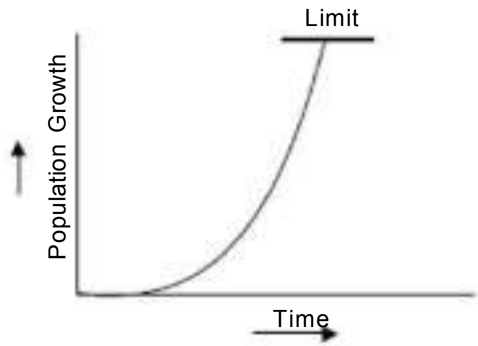

Fig. 6.3. J-shaped growth curve

6.1.2. Factors Controlling Population Growth

There are various factors which has direct or indirect effects on growth of population. These factors are categorised in three groups

1. **Geographic factors:** Like climate, soil, water, mineral resources, transportation etc.

2. **Demographic factors:** Like birth rates (**natality**), death rates (**mortality**), sex ratio etc.
3. **Socio-economic factors:** Like marriages, job availability, resources etc. In the developed countries, population has started declining because of-
   a. Better medical and family planning facilities.
   b. The low death and high birth rates. .
   c. The educated people who know about 'the abuses of overpopulation have small family.

Besides these major factors there are other events or facts that affect population growth of a nation. These include:

1. Occurrence of famines in a country.
2. Natural calamities like floods, droughts, earthquakes and volcanic eruptions, hurricanes etc. which lead to death of thousands of people.
3. Epidemic diseases, endemic diseases wipe a big number of populations.
4. Wars cause heavy casualties.
5. Unnatural accidents caused during transportation, fires etc.

6.1.3. Population Growth: Variation Among Nations

The world population is growing at present at alarming pace. More than 90 million individuals are added to this population every year. Out of this growth 93% is in developing countries. In the past, population growth was a gradual phenomenon and the Earth's ability to replenish resources was capable of adjusting to this increase. In the recent past, the escalation in growth of human numbers has become a major cause of our environmental problems. The needs of this huge number of human beings cannot be supported by the Earth's limited natural resources, without degrading the quality of human life. In some countries, food shortage has become a permanent feature. Two of every three children in South Africa are underweight. In other regions famines due to drought have become more frequent. The developmental strategies at present have not been able to successfully address the problems related to hunger and malnutrition. Excessive extraction of natural resources to provide food and other commodities to growing population is causing environmental problems particularly in the developing world. Use of fertilizers and pesticides to increase crop production to meet food requirements is causing land and water pollution.

On one hand population growth is very less in developed countries. Some nations in Europe like France exhibit negative population growth. Availability or resources and per capita income in these countries is higher. Only 15% of the world's population in the developed world is earning 79% of income!

On the other hand population growth is very high in Asian and African countries where as resources and per capita income in these countries is very low. Thus the disparity in the extent of per capita resources that are used by people who live in a '**developed**' country as against those who live in a '**developing**' country is extremely large. Similarly, the disparity between the rich and the poor in India is also growing.

World has a 7.2 billion human population at present. China is the most populous country in the world. India is next to China in this regard with a population of 1.29 billion. At present population growth rate in India is 1.2%.

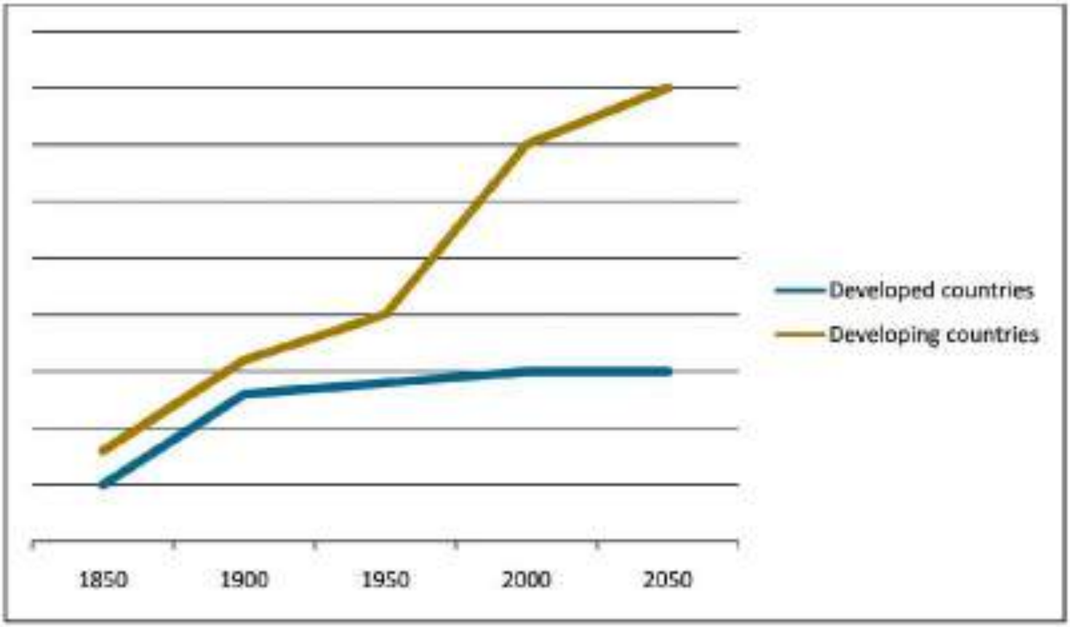

Fig. 6.4. Population growth trends in developed and developing countries

6.1.4. Population Explosion and the Environment

Population explosion is a term used to denote the tremendous increase in human population. As against limited resources increasing populations are causing very problems particularly in poor and developing nations. There are various other problems linked with population explosion such as

- It leads to depletion of resources.
- Rapid pollution of environment
- Un-employment problem
- Severe competition for food and space.
- Increase in psychological stress and strain.
- Large scale unemployment.

6.1.5. Population Control: Family Welfare Programme

Realising the need to curb growing population worldwide polices have been framed and various schemes have been launched to control population growth. Governments all over world have started population control programmes and have also achieved success. Population growth in developed countries has reduced significantly due to governmental initiatives and public awareness. In India too population growth rate has been controlled to some extent during preceding decades due to massive awareness programmes at national scale. Family Welfare Programme has been launched under the central ministry of health to aware people about health and population. Public is educated about the advantages and methods of restricting family size.

The phrase **family planning** is used to indicate a deliberate effort to restrict the growth of family by and the adoption of suitable methods. Family planning, thus, involves a deliberate limitation on the size of family. Family planning programme was started in India in 1952 when its population was nearly 400 million only. In 1978, the government raised the legal minimum age of marriage from 18 to 21 for men and 15 to 18 years for women. World Health Orgaization (WHO) estimates that today about 50 percent of the world's married couples adopt some family planning measures as compared to just 10% about 30 years back.

Under Family planning programme sterilization and other family control measures are done in addition to awareness of the public. There are various methods or measures that can be adopted by couples to keep small family size. These measures or methods are:

1. **Use of contraceptives:** Contraception means the prevention of conception. There are many contraceptive techniques available for use such as:
   - **Mechanical methods** such as:
     - o Condom for male
     - o Diaphragm for female (it is a rubber cup stretched over collapsible metal spring coil. It is designed to fit over the cervix (the mouth of uterus).
     - o Intrauterine Contraceptive Device (IUD)
   - **Chemical Contraceptives**:
     - o Jellies, creams and foam: A number of different spermicidal jellies, creams, and foams are available for use of contraceptive agents. These jellies, creams or foams are inserted into vagina five to fifteen minutes before copulation to take place.
     - o Oral: they are popularly known as pills and can be taken before or after having sex. They prevent sperms from fertilizing the ovum.

- **Natural**: There are certain natural contraceptive methods practised by people
  - o **Abstinence** from sexual act
  - o Coitus interrupts
  - o Safe period

2. **Sterilization:** Sterilisation is done by a minor surgery. It is very simple procedures, done under local anaesthesia and is painless and patients have no post operative problems.
   - **Tubectomy** in females is done by tying the tubes (the fallopian tubes) that carry the ovum to the uterus.
   - **Vasectomy** or Male sterilization is done by tying the tubes(vesa differentia) that carry the sperm. It does not cause any loss in the male's sexual ability but only arrests the discharge of sperm.
3. **Abortion:** It is a deliberate termination of pregnancy and is done either surgically or through certain medicines. It, however, should be avoided in latter stages of pregnancy.

6.2. ENVIRONMENTAL EDUCATION

Environmental Education refers to the organized efforts to teach people about how natural environment functions and how man should manage it for a sustainable living. The goals of Environmental Education are to develop concern and awareness among world population about the total environment and its associated problems and commitment to work individually and collectively towards solution of current problems and the prevention of new ones. So its main aim is:

- To improve the quality of environment.
- To create awareness among the people on environmental problems and conversation.
- To create an atmosphere so that people participate in decision-making

Objectives

The main objectives of Environmental Educational are to increase the awareness level in the society, to develop an environment friendly attitude and to enable the society do something to protect the environment. These objectives can be simplified as:

- **Awareness.** To assist individuals and groups in society to acquire a greater sensitivity and awareness of the environment and its problems.
- **Knowledge.** To assist people acquire a basic understanding of the environment and its problems. It also involves the understanding of the presence and role of man in his environment.
- **Attitudes.** To bring an attitudinal or behavioural change among the people to protect environment.

- **Skills.** To help people acquire the skills needed to solve environmental problems.
- **Capacity to evaluate.** To develop a logical and ethical thinking towards environment and environmental issues.
- **Participation.** To assist individuals and groups in society to develop their sense of responsibility and take note of the urgent need to pay attention to environmental problems.

Formal and Non-formal Environmental Education

To achieve the above said objectives Environmental Education is being imparted to various groups of society. Various aspects of environment and its conservation are taught to the general public in various ways. In formal education, Environmental Science has been introduced as a separate subject at school, college and university levels.

At primary level the emphasis in the subject of Environmental Science is mostly on building up awareness level of the students. Whereas at secondary level students are made familiar with functioning of the environment and its various aspects. At higher secondary level complex functioning of environment is taught to the students. UGC has made teaching of an introductory course in Environmental Studies compulsory for all college level students since 2004.

Non-formal environmental education involves the spread of awareness about environmental issues through adult education, special awareness compaings, conservation camps, NGOs, eco-development camps, conservation practices, training programmes, mass media, etc.

6.3. ECO-MARKETING

Cambridge Dictionary defines ‘Ecomarketing’ as marketing for a product that emphasizes the fact that it does not harm the environment. Green, environmental and eco-marketing are part of the new marketing approaches which do not just refocus, adjust or enhance existing marketing thinking and practice, but seek to provide a substantially different perspective.

Green marketing is the marketing of products that are presumed to be environmentally safer and preferable to others. Thus green marketing incorporates a broad range of activities, including product modification, changes to the production process, sustainable packaging, as well as modifying advertising. Other similar terms used are **environmental marketing** and **ecological marketing**

Eco-friendly products are those products which do not harm the environment in their production, use or disposal. These products in fact help in protecting environment in certain ways as manufacturing and use of such products does not cause pollution. Some of the eco-friendly products are called so because they consume less energy, emits no or little green house gases or do not release toxic substances. Such products are sometimes manufactured through recycling of materials and can also be recycled after their use. Such products also reduce the use of new raw material and hence help in conserving natural resources.

Eco-friendly products may also be biodegradable, recyclable or compostable. So they do not pose any environmental threat when they are disposed of. Examples include biodegradable plastic, recycled paper, etc.

Companies use **eco-marks** to label eco-friendly products. However sometimes this labeling is ambiguous and is only meant for marketing purposes to woo the customers.

Most of traditional products used in rural traditional societies are eco-friendly in their production and use. Use of cotton bag instead of polythene bags, grass mats instead, cow dung, etc are some examples of comparatively safer products used in rural areas.

6.4. MASS MEDIA AND ENVIRONMENTAL ORGANIZATIONS

Present is the era of communication. Information technology has revolutionized the world. Printing press, radio, TV, telephonic system and internet are the modern tools of communication. They play pivotal role in spreading of information and building public opinion. These resources can be effectively used to raise public awareness about environment. Informative programmes broadcast through radio and TV is useful to inform public particularly in rural areas. They can also be used to alert the public about some disasters or epidemics. Public can be guided on various aspects of conservation of wildlife. There should be radio and TV channels dedicated to environmental causes.

Internet and social networking sites are another very effective means of communication, which can be used for disseminating information on environmental issues. Informative and opinion making articles on websites and social groups can serve conservational purposes. Awareness and conservation programmes can be launched through these social media sites. There are thousands of social media groups also actively involved on ground for conservation and protection of environment.

There are various organizations and agencies involved in environmental protection in one way or the other throughout the world. United Nations is one such international organization that has played key role in the world for environmental causes. Some of such organizations are:

- Earth System Governance Project (ESGP)
- Global Environment Facility (GEF)
- Intergovernmental Panel on Climate Change (IPCC)
- International Union for Conservation of Nature (IUCN)
- United Nations Environment Program (UNEP)

- o World Nature Organization (WNO)
- o Centre for Science and Environment (CSE)
- o World Wide Fund for Nature (WWF)
- o United Nations Environment Program (UNEP)
- o Greenpeace
- o Friends of the Earth.

These organisations have played significant role in generating awareness about environment, undertaking major research and educational programmes and launching conservation projects throughout the planet. They have been involved in policy making and finding solutions to serious environmental problems. The attitudinal change at national and global level has been brought about due to various endeavours undertaken by these organisations.

There have been several Government and Nongovernment organizations that have led to environmental protection in our country. They have led to a growing interest in environmental protection and conservation of nature and natural resources. A brief account of some of these organisations is being reproduced her from a UGC publication.

The traditional conservation practices that were part of ancient India's culture have however gradually disappeared. Public awareness is thus a critical need to further environmental protection. Among the large number of institutions that deal with environmental protection and conservation, a few well-known organizations include government organisations such as the BSI and ZSI, and NGOs such as BNHS, WWF-I, etc.

Bombay Natural History Society (BNHS), Mumbai: the BNHS began as a small society of six members in 1883. It grew from a group of shikaris and people from all walks of life into a major research organisation that substantially influenced conservation policy in the country.

The influence on wildlife policy building, research and popular publications and peoples action have been unique features of the multifaceted society. Undoubtedly its major contribution has been in the field of wildlife research. It is India's oldest conservation research based NGO and one that has acted at the forefront of the battle for species and ecosystems. The BNHS publishes a popular magazine called Hornbill and also an internationally well-known Journal on Natural History. Its other publications include the Salim Ali's Handbook on Birds, JC Daniel's book of Indian Reptiles, S H Prater's book of Indian Mammals and PV Bole's book of Indian Trees. One of its greatest scientists was Dr. Salim Ali whose ornithological work on the birds of the Indian subcontinent is world famous. The BNHS has over the years helped Government to frame wildlife related laws and has taken up battles such as the 'Save the Silent Valley' campaign.

World Wide Fund for Nature-India (WWF-I), New Delhi: The WWF-I was initiated in 1969 in Mumbai after which the headquarters were shifted to Delhi with several branch offices all over India. The early years focused attention on wildlife education and awareness. It runs several programs including the Nature Clubs of India program for school children and works as a think tank and lobby force for environment and development issues.

Centre for Science and Environment (CSE), New Delhi: Activities of this Centre include

Organising campaigns, holding workshops and conferences, and producing environment related publications. It published a major document on the 'State of India's Environment', the first of its kind to be produced as a Citizen's Report on the Environment. The CSE also publishes a popular magazine, 'Down to Earth', which is a Science and Environment fortnightly. It is involved in the publication of material in the form of books, posters, video films and also conducts workshops and seminars on biodiversity related issues.

Salim Ali Centre for Ornithology and Natural History (SACON), Coimbatore: This institution was Dr. Salim Ali's dream that became a reality only after his demise. He wished to support a group of committed conservation scientists on a permanent basis. Initially conceived as being a wing of the Bombay Natural History Society (BNHS) it later evolved as an independent organisation based at Coimbatore in 1990. It has instituted a variety of field programs that have added to the country's information on our threatened biodiversity.

Wildlife Institute of India (WII), Dehradun: This Institution was established in 1982, as a major training establishment for Forest Officials and Research in Wildlife Management. Its most significant publication has been 'Planning Wildlife Protected Area Network for India' (Rodgers and Panwar, 1988). The organisation has over the years added an enormous amount

of information on India's biological wealth. It has trained a large number of Forest Department Officials and Staff as Wildlife Managers. Its M.Sc. Program has trained excellent wildlife scientists. It also has an Environment Impact Assessment (EIA) cell. It trains personnel in ecodevelopment, wildlife biology, habitat management and Nature interpretation.

Botanical Survey of India (BSI): The Botanical Survey of India (BSI) was established in 1890 at the Royal Botanic Gardens, Calcutta. However it closed down for several years after 1939 and was reopened in 1954. In 1952 plans were made to reorganise the BSI and formulate its objectives. By 1955 the BSI had its headquarters in Calcutta with Circle Offices at Coimbatore, Shillong, Pune and Dehra Dun. Between 1962 and 1979, offices were established in Allahabad, Jodhpur, Port Blair, Itanagar and Gangtok. The BSI currently has nine regional centres. It carries out surveys of plant resources in different regions.

Zoological Survey of India (ZSI): The ZSI was established in1916. Its mandate was to do a systematic survey of fauna in India. It has over the years collected 'type specimens' on the bases of which our animal life has been studied over the years. Its origins were collections based at the Indian Museum at Calcutta, which was established in 1875. Older collections of the Asiatic Society of Bengal, which were made between 1814 and 1875, as well as those of the Indian Museum made between 1875 and 1916 were then transferred to the ZSI. Today it has over a million specimens. This makes it one of the largest collections in Asia. It has done an enormous amount of work on taxonomy and ecology. It currently operates from 16 regional centres.

6.5. ENVIRONMENTAL MOVEMENTS IN INDIA

Environmental movement may be defined as a social, ethical and political movement to improve and protect the quality of the natural environment. These movements owe their origin to the increasing levels of smoke in the air during the Industrial Revolution. The emergence of various types of factories and large scale consumption of coal by them gave rise to an unprecedented level of atmospheric pollution. This alerted the people and they started who coming out against increasing pollution.

Generally environmental movements aim at conservation of environment, biodiversity and natural resources. Overexploitation of environment in certain regions has led to the origin some conservation movements specifically focusing on the conservation of environment in the region. Chipko movement originated in response to indiscriminate felling of green treesin the northern India. Narmada Bachao Andolan and Silent valley movements owe their origin to the proposed projects on Narmada River and in silent valley tropical forests.

Chipko Movement

In India an organized resistance to the destruction of forests spread throughout the country and came to be known as the Chipko movement. The name of the movement comes from the word 'embrace', as the villagers hugged the trees, and prevented the contractors' from felling them.

The first Chipko action took place spontaneously in April 1973 in the village of Mandal in the upper Alakananda valley and over the next five years spread to many districts of the Himalayas in Uttar Pradesh. It was sparked off by the government's decision to allot a plot of forest area in the Alaknanda valley to a sports goods company. This angered the villagers because their similar demand to use wood for making agricultural tools had been earlier denied. With encouragement from a local organization DGSS (Dasoli Gram Swarajya Sangh), the women of the area, under the leadership of an activist, Chandi Prasad Bhatt, went into the forest and formed a circle around the trees preventing the men from cutting them down.

The success achieved by this protest led to similar protests in other parts of the country. From their origins as a spontaneous protest against logging abuses in Uttar

Pradesh in the Himalayas, supporters of the Chipko movement, mainly village women, have successfully banned the felling of trees in a number of regions and influenced natural resource policy in India. The success of the Chipko movement in the hills saved thousands of trees from being felled.

Some other persons have also been involved in this movement and have given it proper direction. Mr Sunderlal Bahuguna, a Gandhian activist and philosopher, whose appeal to Mrs Indira Gandhi, the then Prime Minister of India, resulted in the green-felling ban. Mr Bahuguna coined the Chipko slogan: 'ecology is permanent economy'.

The Chipko protests in Uttar Pradesh achieved a major victory in 1980 with a 15-year ban on green felling in the Himalayan forests of that state by the order of Mrs Indira Gandhi, the then Prime Minister of India. Since then, the movement has spread to many states in the country. In addition to the 15-year ban in Uttar Pradesh, the movement has stopped felling in the Western Ghats and the Vindhyas and has generated pressure for a natural resource policy that is more sensitive to people's needs and ecological requirements.

Narmada Bachao Andolan

Narmada Bachao Andolan is the most powerful mass movement, started in 1985, against the construction of huge dam on the Narmada river. Narmada is the India's largest west flowing river, which supports a large variety of people with distinguished culture and tradition ranging from the indigenous (tribal) people inhabited in the jungles here to the large number of rural population. The proposed Sardar Sarovar Dam and Narmada Sagar will displace more than 250,000 people. The big fight is over the resettlement or the rehabilitation of these people. The two proposals are already under construction, supported by US$550 million loan by the World Bank. There are plans to build over 3000 big and small dams along the river.

> Led by one of the prominent leader Medha Patkar, it has now been turned into the International protest, gaining support from NGO'S all around the globe. Protestors are agitating the issue through the mass media, hunger strikes, massive marches, rallies and the through the on screen of several documentary films. Although they have been protesting peacefully, but they been harassed, arrested and beaten up by the police several times. The Narmada Bachao Andolan has been pressurizing the World Bank through media to withdraw its loan from the project
>
> (Courtesy: *SatheeshKalanilayam*)

Narmada Valley Development plan is the most promised and most challenging plan in the history of India. The proponents are of the view that it will produce 1450 MW of electricity and pure drinking water to 40 million people covering thousand of villages and towns. Some of the dams have been already been completed such as Tawa and Bargi Dams. But the opponents say that this hydro project will devastate human lives and biodiversity by destroying thousands of acres of forests and agricultural land. On the other hand it will overall deprive thousands of people of their livelihood. They believe that the water and energy could be provided to the people through alternative technological means that would be ecologically beneficial.

Silent Valley Movement

Silent valley is an evergreen tropical forest in the Palakkad district of Kerala, India. **Save Silent Valley** was a social movement aimed at the protection of this forest region. It was started in 1973 to save this region from being flooded by a hydroelectric project. Finally the valley was declared as Silent Valley National Park in 1985.

A major river flows through the lush green forests of Silent Valley. The state government announced the construction of a dam at on this river. It was in 1928 when a British technical expert suggested that hydel power can be generated easily from this river. The first survey on this project was carried out in 1958 and the Planning Commission approved it in 1973. The project planned to generate 120 megawatt of electricity initially and 240 megawatt subsequently.

After the announcement of imminent dam construction the valley became the focal point of the environmentalists who believe that the project would result in the destruction of the richest expression of life that has evolved on this planet'. The forests of Silent Valley are very rich in biodiversity. They are home to the largest population of lion-tailed macaque. They are among the world's rarest and most threatened primates. Because of concern about the endangered lion-tailed macaque, the issue was brought to public attention. There started Save Silent Valley movement to stop the government from going ahead with the proposed project. Romulus Whitaker, founder of the Madras Snake Park and the Madras Crocodile Bank, was probably the first person to draw public attention to the small and remote area. In 1977 the Kerala Forest Research Institute carried out an ecological impact study of the Silent Valley area and proposed that the area be declared a biosphere reserve. A task-force was formed under the leadership of the then Vice-President of the World Wildlife Fund, India. The task-force in its survey-report, also advised not to undertake the project.

In 1978 Government of India again approved the project, with the condition that the state government enact legislation ensuring the necessary safeguards. However environmentalists continued their protests and emphasasized the protection of entire region demanding complete ban on any such projects.

A petition was filed before the High Court of Kerala, against the clear cutting of forests in the hydroelectric project area and the court ordered a stop the clear cutting. But in January 1980 the High Court of Kerala lifted the ban on clear cutting. However the then Prime Minister of India requested the Government of Kerala to stop further works in the project area until all aspects were fully discussed. In December, the Government of Kerala declared the Silent Valley area, excluding the hydroelectric project area, as a national park. Finally the Government of India, after a careful study of the Menon Report, decided to abandon the Project.

RECAPS AND PRACTICES

Walk and Talk

(Facts in brief)

- Human Population is growing and has crossed 7.21 billion at present.
- India stand second after China in its population with its current population more than 1.2 billions
- In J&K state its 98% population resides in Jammu and Kashmir division and 2% in Ladakh (Leh and Kargil). 58% of total land of state lies in Ladakh.
- Humanity faces many health related challenges at present.
- Majority of health related issues are linked with environmental pollution and unhygienic living conditions have been caused due to various types of pollution.
- Health problems in many areas have been caused due to various types of pollution.
- Some of the world's worst natural disasters are:
  - o 1931 Flood in China, occurred in July-august, 1931 and death toll was estimated between 10,00,000-40,00,000.
  - o 1976 Tangshan earthquake occurred on July 28,1976 in China. Death toll was 450,000.
  - o Earthquake in Gujarat on January 26, 2001caused death of 12300 and tremendous property loss in Bhuj area of the state.
  - o Earthquake and Tsunami in Indian ocean on December 26, 2004 resulted in 2,80,000 deaths in India and Indonesia.
  - o Cyclone Nargis in Myanmar on May 2, 2008 resulted 1,38,366 deaths.
  - o Haiti earthquake on January 12, 2010 resulted deaths of more than 1,60,000 people.
  - o Earthquake on October 8, 2005 caused death of about 100000 people in Jammu and Kashmir and Pakistan Administered Kashmir.
- Disasters are mostly naturally events but the damages caused by them can be minimized by proper preparations and management
- Man's excessive interference to the natural environment often increases the intensity and frequency of natural disasters and their damage.
- Risk Assessment and Vulnerability Analysis greatly help in disaster management
- Modern technologies like Remote Sensing, Sattellite communication, Global Positiong System(GPS), Geographical Information System(GIS), global meterological networks, etc play vital role in management of disasters and lessening the predictable losses due to them

- Resettlement and rehabilitation of people displaced either due to disasters or due to developmental projects is a serious human problem world over.
- Rehabilitation requires a full-fledged system to be adopted and not an adhoc approach.
- Wastelands and their reclamation is a global environmental issue.
- Land resources are limited and due to faulty approaches of man this limited resource is further shrinking.
- Of 167.5 million sq.km of world's land surface, about 105.5 million sq. km is unproductive which cannot be used for any purpose.
- Deforestation and desertification (expansion of deserts or desert like situation) are causes which ultimately render fertile lands waste and unusable.

Practice and Prepare

(Self Tests)

(Multiple choice objective type questions)

1. At present world population has crossed
   a. 2 billion b. 20 billion
   c. 7 billion d. 6 billion **Ans. c**

2. When Age structure figure is bell shaped, it means population is
   a. Stable b. Decreasing
   c. Increasing d. None of the above **Ans. a**

3. Every ....person in the world is an Indian
   a. 4^{th} b. 15^{th}
   c. 9^{th} d. 6^{th} **Ans. d**

4. Population does not include
   a. Weak and unhealthy individuals b. Individuals of other species
   c. Aged individuals d. Immigrants **Ans. b**

5. Which among the following does not affect population growth
   a. Natality rate b. Mortality rate
   c. Emigration d. Change of government **Ans. d**

6. Human population is …….. on the surface of the earth
   a. Unevenly distributed
   b. Distributed as per available resources
   c. Uniformly distributed
   d. None of the above **Ans. a**

7. Population growth is highest in
   a. European countries b. Australia
   c. Japan d. Asian countries **Ans. d**
8. When number of individuals added and lost in a population is same, it is called
   a. Uniform growth b. Zero growth
   c. Lowest growth d. Highest growth **Ans. b**
9. Family Planning Programme started in India in
   a. 1990 b. 1952
   c. 1947 d. 1876 **Ans. b**
10. Diaphragm is used by female for birth control is a
    a. Mechanical measure b. Chemical used
    c. Natural instrument d. Biological measure **Ans. a**
11. A devastating earthquake occurred in 2001 in
    a. Punjab b. Maharashtra
    c. Gujarat d. Bihar **Ans. c**
12. 'Hurricanes', 'Typhoons' and 'Willy witlies' are the types of
    a. Cyclones b. Droughts
    c. Tsunamis d. None of the above **Ans. a**
13. Tsunamis are result of
    a. Earthquake b. Cyclone
    c. Drought d. Landslide **Ans. a**
14. Maximum area of wastelands occurs (in India) in
    a. Madhya Pradesh b. Andhra Pradesh
    c. Rajasthan (36 million hectares) d. Kashmir **Ans. c**
15. Which among the following is not a wasteland reclamation practice
    a. Leaching b. Drainage
    c. Afforestation d. Deforestation **Ans. d**
16. Waves generated by earthquake are known as
    a. E M waves b. Seismic waves
    c. Primary waves d. Sea waves **Ans. b**
17. Which among the following cannot be a cause of earthquake
    a. Volcanic eruption b. Damming of water
    c. Landslides d. Underground nuclear tests **Ans. c**

18. Cyclones occur frequently in
    a. Tropical regions b. Polar regions
    c. Temperate regions d. None of the above **Ans. a**

19. Which among the following cannot be a cause of landslides
    a. Deforestation b. Drought
    c. Heavy rainfall d. Earthquake **Ans. b**

20. State of Jammu and Kashmir comes under
    a. Earthquake prone region b. Cyclone prone region
    c. Tsunami prone region d. Drought prone region **Ans. a**

21. Which among the following is a landslide prone area
    a. Jammu and Kashmir b. Rajasthan
    c. Kerala d. Maharashtra **Ans. a**

22. In September 2014 Jammu and Kashmir state witnessed
    a. Earthquake b. Drought
    c. Flood (and landslides) d. None of the above **Ans. c**

23. On April 25, 2015, an earthquake of 7.5 magnitude on Richter scale occurred in
    a. Egypt b. Nepal (and also in parts of India)
    c. Pakistan d. Myanmar **Ans. b**

24. Which among the following is not a natural disaster
    a. Tsunami b. Drought
    c. Deforestation d. Cyclone **Ans. c**

25. Which among the following is a natural disaster
    a. Pollution b. Nuclear explosion
    c. Flood d. AIDS **Ans. c**

26. Natural disasters are
    a. Predictable b. Predictable to some extent
    c. Unpredictable d. Mostly unpredictable **Ans. d**

27. Drought is a
    a. Pollution related problem b. Natural disaster
    c. Water logging problem d. Manmade disaster **Ans. b**

28. Nuclear accidents and holocaust is a
    a. Natural disaster b. Manmade disaster
    c. Energy consuming process d. Energy providing technique **Ans. b**

29. Earthquake of 4.0 to 4.9 magnitude on Richter scale are considered to be

a. Great	b. Destructive
c. Minor	d. Insignificant **Ans. c**

30. The point at which first movement occurs during an earthquake iscalled

a. Epicenter	b. Focus
c. Fault zone	d. Focal point **Ans. a**

Chapter 7

Environmental Ethics and Laws

Nothing living should be treated with contempt. What it is that lives, a man, a tree or a bird should be touched gently. Civilization is another word for respect of life.

Elizbeth Goudge

Objectives

In this unit, we will learn about:

- ✓ Environmental ethics, issues and possible solutions
- ✓ Environmental laws and salient features of some environmental acts of India
  - o Types of Environmental Laws
  - o Wildlife protection Act, 1972.
  - o Water (Prevention and control of pollution) Act, 1974.
  - o Forest conservation Act, 1980
  - o Air (Prevention and control of pollution) Act, 1981.
  - o Environmental Protection Act, 1986.
  - o Important International Treaties, Agreements and Conventions For Environmental Protection
  - o Brief summary of environmental legislation and their amendments

CHAPTER 7 ENVIRONMENTAL ETHICS AND LAWS

We must develop a better sense of responsibility towards our total environment

Jon Wynne Tyson

ABSTRACT

Uncontrolled human activities are the main cause of environmental degradation. Law is a regulator of human conduct in the modern era and it can become an effective tool in achieving the goals of environmental protection and sustainable development. In India various environmental laws are operative since decades back. These have regularly been modified from time to time in order to make them more effective and implementable in the changing scenarios. There are water and air pollution prevention acts regulating the human activities which contribute to pollution. Central and state pollution control boards are created as legal or constitutional bodies to control pollution and suggest preventive measures besides doing research. Forest and wildlife protection acts deal with various issues relevant to deforestation and illegal poaching.

Environmental ethics relates to human beings' ethical relationship with the natural environment. It is the philosophical discipline that considers the moral and ethical relationship of human beings to the environment and is based on the moral obligation humans have to the preservation and care of the non-human world.

INTRODUCTION AND DISCUSSION

7.1. ENVIRONMENTAL ETHICS

The word ethics is originally derived from a Greek word 'ethos' that means character. It refers to one's belief, values, behaviour and actions which collectively shape the character of an individual in the society and that of the society as a whole. It also refers to one's ability to distinguish between what is right and what is wrong. Though the notion of right and wrong or the values has varied from time to time and with people to people, there are certain ethical principles which have been universally accepted. It is these universally accepted ethical values which can be helpful and guiding principles for humanity to save environment. Environmental ethics can be defined as the philosophical discipline that considers the moral and ethical relationship of human beings to the environment. It is, therefore, a system of ethical values that compel man for right conduct of environment.

Environmental ethics helps define man's moral and ethical obligations toward the environment. Human values become a factor when looking at environmental ethics. Human values are the things that are important to individuals that they then use to evaluate actions or events. In other words, humans assign value to certain things and then use this assigned value to make decisions about whether something is right or wrong. Water and air pollution, the depletion of natural resources, loss of biodiversity, destruction of ecosystems, and global climate change are all part of the environmental ethics debate.

7.1.1 Guiding principles of environmental ethics

Asthana and Asthana (2009) lists following as what should be the guiding principles of environmental ethics (are being given here with slight modifications)

1. The distribution of the resources of the world should be egalitarian as far as possible.
2. All humans are equal. For all there should be equal opportunities to compete for the comforts world.
3. The rights of the environment and natural resources should take precedence over the right of individuals as they are linked to the welfare of entire biosphere

Some important directives of environmental ethics are based on:

1. Individuals obligation to the community and the society
2. The rights of nature
3. Our obligations to the future generation

Environmental ethics discusses the issues, principles and guidelines relating to human interactions with their environment. Environmental crises are in fact the reflection of our mental behaviour and attitudes towards rest of the world. It all is related to how do we think of other living beings and treat them. If we think man is all powerful and the supreme creature on this earth and man is the master of nature and can harness it at his will, it reflects our highly human-centric thinking. On the other hand, if we consider Mother Nature as provider of all the resources for leading a beautiful life and understand that she nourishes us like a mother, we should respect her. This is an earth-centric thinking. The first view urges us to establish our supremacy over nature through technological innovations, economic growth and development without much botheration to care for the damage done to the planet earth. The second view urges us to live on this earth as a part of it, like any other creation of Nature and live sustainably. Our acts, thus, follow what we think. If we want to check the environmental crisis, we will have to transform our thinking and attitude. That in turn, would transform our deeds, leading to a better environment and better future.

Environmental ethics promotes an eco-friendly thinking and urges man to adopt a worldview which is not anthropocentric (man focussed) but one in which he co exists with nature. Important points of this kind of thinking include:

(i) Nature exists not for human beings alone, but for all the species present on the earth.

(ii) The natural resources are limited and they do not belong only to human beings or present generation of human beings but they are rather shared by all including other life forms and future human generations.

(iii) Economic growth is good till it sticks to least damage to the earth environment.

(iv) A healthy economy depends upon a healthy environment.

(v) The success of mankind depends upon how best we can cooperate with the rest of the nature while trying to use them for our benefit.

Environmental ethics can provide us the guidelines for putting our beliefs into action and help us decide what to do when faced with crucial situations.

Kaushik and Kaushik (2004) gives some important ethical guidelines known as Earth ethics or Environmental Ethics as follows:

- You should love and honour the earth since it has blessed you with life and governs your survival.
- You should keep each day sacred to earth and celebrate the turning of its seasons.
- You should not hold yourself above other living things and have no right to drive them to extinction.
- You should be grateful to the plants and animals which nourish you by giving you food.
- You should limit your offsprings because too many people will overburden the earth.
- You should not waste your resources on destructive weapons.
- You should not run after gains at the cost of nature, rather should strive to restore its damaged majesty.

- You should not conceal from others the effects you have causedby your actions on earth.
- You should not steal from future generations their right to live in a clean and safe planet by impoverishing or polluting it.
- You should consume the material goods in moderate amounts so that all may share the earth's precious treasure of resources.

If we critically go through the above Ten Commandments for earth ethics and reflect upon the same, we will find that various religions teach us the same things in one form or the other. Our Vedas have glorified each and every component of nature as gods or goddesses so that people have a feeling of reverence for them. Our religious and cultural rituals make us perform such actions that would help in the conservation of nature and natural resources. The concept of ahimsa (non-violence) in Buddhism and Jainism ensure the protection and conservation of all forms of life, thereby keeping the ecological balance of the earth intact.

7.2 ENVIRONMENTAL LAWS

Principles, policies, directives and regulations enacted and enforced by different authorities in their respective areas with objectives to protect natural environment comes under the purview of environmental laws. The deteriorating environment, disappearing biodiversity, climatic changes, etc at global scale have compelled the world nations to act and strategize for environmental protection. This realization has led to the formation of a framework of treaties and agreements at international level to regulate human behavior in order to save his environmental assets. In order to comply with international agreements countries of the world have to undertake legislative measures at national levels.

7.2.1 Types of environmental laws

Most of the environmental laws formulated by different countries of the world fall under following categories

1. Command and control legislation
2. Laws making environmental assessment mandatory
3. Laws involving incentives or deterrents
4. Set aside schemes

The design and implementation of most of the environmental legislation have been shaped and guided by a set of principles such as:

1. The precautionary principle
2. The preventive principle
3. The ''polluter-pays" principle
4. The public participation principle

India is among the pioneer countries in the world to have made provisions for the protection and conservation of environment in its constitution. Environment was discussed as an item of international agenda for the first time on 5th June, 1972, in the U.N. Conference on Human Environment in Stockholm. This date is thereafter celebrated all over the world as World Environment Day. Soon after the Stockholm Conference our country took substantive legislative steps for environmental protection. The Wildlife (Protection) Act was passed in 1972, followed by the Water (Prevention and Control of Pollution) Act 1974, the Forest (Conservation) Act, 1980, Air (Prevention and Control of Pollution) Act, 1981and subsequently the Environment (Protection) Act, 1986. Moreover within four years of

Stockholm Conference, the provisions for environmental protection were made in the Indian constitution through the 42nd amendment as follows:

Article 48-A of the constitution provides: The state shall endeavour to protect and improve the environment and to safeguard forests and wildlife of the country.

Article 51A (g) provides: .It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures.

Thus the constitution itself includes environmental protection and conservation as one of our fundamental duties. Some of the important Acts passed by the Government of India are discussed here.

7.2.2. Wildlife (Protection) Act, 1972

This act is a landmark in the history of wildlife legislation in the country. it came into existence on September 9, 1972. The major activities and provisions in the act can be summed up as follows:

(i) It defines the wild-life related terminology.

(ii) It provides for the appointment of wildlife advisory Board, Wildlife warden, their powers, duties etc.

(iii) Under the Act, comprehensive listing of endangered wild life species was done for the first time and prohibition of hunting of the endangered species was mentioned.

(iv) (iv) Protection to some endangered plants like Beddome cycad, Blue Vanda, Ladies Slipper Orchid, Pitcher plant etc. is also provided under the Act.

(v) The Act provides for setting up of National Parks, Wildlife Sanctuaries etc.

(vi) The Act provides for the constitution of Central Zoo Authority.

(vii) There is provision for trade and commerce in some wildlife species with license for sale, possession, transfer etc.

(viii) The Act imposes a ban on the trade or commerce in scheduled animals.

(ix) It provides for legal powers to officers and punishment to offenders.

(x) It provides for captive breeding programme for endangered species.

Several Conservation Projects for individual endangered species like lion (1972) Tiger (1973), Crocodile (1974) and Brown antlered Deer (1981) were started under this Act. The Act is adopted by all states in India except J & K which has its own Act.

Some of the major drawbacks of the Act include mild penalty to offenders, illegal wild life trade in J & K, personal ownership certificate for animal articles like tiger and leopard skins, no coverage of foreign endangered wildlife, pitiable condition of wildlife in mobile zoos and little emphasis on protection of plant genetic resources.

7.2.3 Water (Prevention And Control Of Pollution) Act, 1974

It provides for maintaining and restoring the wholesomeness of water by preventing and controlling its pollution. The act came into force on March 23, 1974. Pollution is defined as such contamination of water, or such alteration of the physical, chemical or biological properties of water, or such discharge as is likely to cause a nuisance or render the water harmful or injurious to public health and safety or harmful for any other use or to aquatic plants and other organisms or animal life.

The definition of water pollution has thus encompassed the entire probable agents in water that may cause any harm or have a potential to harm any kind of life in any way.

The salient features and provisions of the Act are summed up as follows:

(i) It provides for maintenance and restoration of quality of all types of surface and ground water.

(ii) It provides for the establishment of Central and State Boards for pollution control.

(iii) It confers them with powers and functions to control pollution. The Central and State Pollution Control Boards are widely represented and are given comprehensive powers to advise, coordinate and provide technical assistance for prevention and control of pollution of water.

(iv) The Act has provisions for funds, budgets, accounts and audit of the Central and State Pollution Control Boards.

(v) The Act makes provisions for various penalties for the defaulters and procedure for the same.

The main regulatory bodies are the Pollution Control Boards, which have been, conferred the following duties and powers:

Central Pollution Control Board (CPCB):

- It advises the central govt. in matters related to prevention and control of water pollution.

- Coordinates the activities of State Pollution Control Boards and provides them technical assistance and guidance.
- Organizes training programs for prevention and control of pollution.
- Organizes comprehensive programs on pollution related issues through mass media.
- Collects, compiles and publishes technical and statistical data related to pollution.
- Prepares manuals for treatment and disposal of sewage and trade effluents.
- Lays down standards for water quality parameters.
- Plans nation-wide programs for prevention, control or abatement of pollution.
- Establishes and recognizes laboratories for analysis of water, sewage or trade effluent sample.

The State Pollution Control Boards also have similar functions to be executed at state level and are governed by the directions of CPCB.

- The Board advises the state govt. with respect to the location of any industry that might pollute a stream or a well.
- It lays down standards for effluents and is empowered to take samples from any stream, well or trade effluent or sewage passing through an industry.
- The State Board is empowered to take legal samples of trade effluent in accordance with the procedure laid down in the Act. The sample taken in the presence of the occupier or his agent is divided into two parts, sealed, signed by both parties and sent for analysis to some recognized lab. If the samples do not conform to the prescribed water quality standards (crossing maximum permissible limits), then .consent. is refused to the unit.
- Every industry has to obtain consent from the Board (granted for a fixed duration) by applying on a prescribed Proforma providing all technical details, along with a prescribed fee following which analysis of the effluent is carried out.
- The Board suggests efficient methods for utilization, treatment and disposal of trade effluents.

The Act has made detailed provisions regarding the power of the Boards to obtain information, take trade samples, restrict new outlets, restrict expansion, enter and inspect the units and sanction or refuse consent to the industry after effluent analysis. While development is necessary, it is all the more important to prevent pollution, which can jeopardize the lives of the people. Installation and proper functioning of effluent treatment plants (ETP) in all polluting industries is a must for checking pollution of water and land. Despite certain weaknesses in the Act, the Water Act has ample provisions for preventing and controlling water pollution through legal measures.

7.2.4. Forest (Conservation) Act, 1980

This act deals with the conservation of forests and related aspects. It came into force on December 27, 1980. Except J & K, the act is adopted all over India. The Act covers under it all types of forests including reserved forests, protected forests or any forested land irrespective of its ownership.

The salient features of the Act are as follows:

(i) The State Govt. has been empowered under this Act to use the forests only for forestry purposes. If at all it wants to use it in any other way, it has to take prior approval of central Government, after which it can pass orders for declaring some part of reserve forest for non-forest purposes (e.g mining) or for clearing some naturally growing trees and replacing them by economically important trees (reforestation).

(ii) It makes provision for conservation of all types of forests and for this purpose there is an Advisory committee which recommends funding for it to the Central Government.

(iii) Any illegal non-forest activity within a forest area can be immediately stopped under this Act. Non-forest activities include clearing of forest land for cultivation of any type of plants/crops or any other purpose (except re-afforestation).However, some construction work in the forest for wildlife or forest management is exempted from non-forest activity (e.g. fencing, making water-holes, trench, pipelines, check posts, wireless communication etc.)(See Appendix 1.)

7.2.5 The Air (Prevention And Control Of Pollution) Act, 1981

The act has important constitutional implications and came into force on 16th of May, 1981. It was also amended in the year 1987. The act draws its inspiration from United Nations Conference on Human Environment held at Stockholm in 1972. India was an important signatory to this conference and hence passed this legislation to implement the provisions contained in conference's declaration.

Salient features of the act are as follows:

(i) The Act provides for prevention, control and abatement of air pollution.

(ii) (ii) In the Act, air pollution has been defined as the presence of any solid, liquid or gaseous substance (including noise) in the atmosphere in such concentration as may be or tend to be harmful to human beings or any other living creatures or plants or property or environment.

(iii) Noise pollution has been inserted as pollution in the Act in1987.

(iv) Pollution control boards at the central or state level have the regulatory authority to implement the Air Act. Just parallel to the functions related to Water (Prevention and Control of Pollution) Act, the boards perform similar functions related to improvement of air quality. The boards have to check whether or not the industry strictly follows the norms or standards laid down by the Board under section17, regarding the discharge of emission of any air pollutant. Based upon analysis report consent is granted or refused to the industry.

(v) Just like the Water Act, the Air Act has provisions for defining the constitution, powers and function of Pollution Control Boards, funds, accounts, audit, penalties and procedures.

(vi) Section 20 of the Act has provision for ensuring emission standards from automobiles. Based upon it, the state govt. is empowered to issue instructions to the authority in-charge of registration of motor vehicles (under Motor Vehicles Act, 1939) that is bound to comply with such instructions.

(vii) As per Section 19, in consultation with the State Pollution Control Board, the state government may declare an area within the state as air pollution control area and can prohibit the use of any fuel other than approved fuel in the area causing air pollution. No person shall, without prior consent of State Board operate or establish any industrial unit in the .air pollution control area.

The Water and Air Acts have also made special provisions for appeals. Under Section 28 of Water Act and Section 31 of Air Act, a provision for appeals has been made. An Appellate Authority consisting of a single person or three persons appointed by the Head of the

State, Governor is constituted to hear such appeals as filed by some aggrieved party (industry) due to some order made by the State Board within 30 days of passing the orders.

The Appellate Authority after giving the appellant and the State Board an opportunity of being heard, disposes off the appeal as expeditiously as possible.

7.2.6 The Environment (Protection) Act, 1986

The Act came into force on Nov. 19, 1986. The Act extends to whole of India. It was also an outcome of UN's Stockholm declaration and the first most comprehensive environmental law to address or deal the grave environmental issues in a more holistic manner.

Important terminology used in the Act: Some terms related to environment have been described as follows in the Act:

(i) Environment includes water, air and land and the inter-relationships that exist among and between them and human beings, all other living organisms and property.

(ii) Environmental pollution means the presence of any solid, liquid or gaseous substance present in such concentration, as may be, or tend to be, injurious to environment.

(iii) Hazardous Substance means any substance or preparation which by its physico-chemical properties or handling is liable to cause harm to human beings, other living organisms, property or environment.

The Act has given powers to the Central Government to take measures to protect and improve environment while the state governments coordinate the actions. The most important functions of Central Govt. under this Act include setting up of:

(a) The standards of quality of air, water or soil for various areas and purposes.
(b) The maximum permissible limits of concentration of various environmental pollutants (including noise) for different areas.
(c) The procedures and safeguards for the handling of hazardous substances.
(d) The prohibition and restrictions on the handling of hazardous substances in different areas.
(e) The prohibition and restriction on the location of industries and to carry on process and operations in different areas.
(f) The procedures and safeguards for the prevention of accidents which may cause environmental pollution and providing for remedial measures for such accidents.

The power of entry and inspection, power to take sample etc. under this Act lies with the Central Government or any officer empowered by it.

For the purpose of protecting and improving the quality of the environment and preventing and abating pollution, standards have been specified under Schedule I- IV of Environment (Protection) Rules, 1986for emission of gaseous pollutants and discharge of effluents/waste water from industries. These standards vary from industry to industry and also vary with the medium into which the effluent in discharged or the area of emission. For instance, the maximum permissible limits of B.O.D. (Biochemical Oxygen Demand) of the waste water is 30 ppm if it is discharged into inland waters, 350 ppm if discharged into a public sewer and 100 ppm, if discharged onto land or coastal region. Likewise, emission standards vary in residential, sensitive and industrial area. Naturally the standards for sensitive areas like hospitals are more stringent. It is the duty of the Pollution Control Board to check whether the industries are following the prescribed norms or not.

Under the Environmental (Protection) Rules, 1986 the State Pollution Control Boards have to follow the guidelines provided under Schedule VI, some of which are as follows:

(a) They have to advise the Industries for treating the waste water and gases with the best available technology to achieve the prescribed standards.
(b) The industries have to be encouraged for recycling and reusing the wastes.
(c) They have to encourage the industries for recovery of biogas, energy and reusable materials.
(d) While permitting the discharge of effluents and emissions into the environment, the State Boards have to take into account the assimilative capacity of the receiving water body.
(e) The Central and State Boards have to emphasize on the implementation of clean technologies by the industries in order to increase fuel efficiency and reduce the

generation of environmental pollutants. Under the Environment (Protection) Rules, 1986 an amendment was made in 1994 for Environmental Impact Assessment (EIA) of Various Development Projects. There are 29 types of projects listed under Schedule I of the rule which require clearance from the Central Government before establishing. Others require clearance from the State Pollution Control Board, when the proposed project or expansion activity is going to cause pollution load exceeding the existing levels. The project proponent has to provide EIA report, risk analysis report, NOC from State Pollution Control Board, Commitment regarding availability of water and electricity, Summary of project report/feasibility report, filled in a questionnaire for environmental appraisal of the project and comprehensive rehabilitation plan, if more than 1000 people are likely to be displaced due to the project.

Under the Environment (Protection) Act, 1986 the Central Government also made the Hazardous Wastes (Management and Handling) Rules, 1989. Under these rules, it is the responsibility of the occupier to take all practical steps to ensure that such wastes are properly handled and disposed off without any adverse effects. There are 18 Hazardous

Waste categories recognized under this rule and there are guidelines for their proper handling, storage, treatment, transport and disposal which should be strictly followed by the owner. The Environment (Protection) Act, 1986 has also made provision for environmental Audit as a means of checking whether or not accompany is complying with the environmental laws and regulations. Thus, ample provisions have been made in our country through law for improving the quality of our environment. (See Appendix 2)

7.3. IMPORTANT INTERNATIONAL TREATIES, AGREEMENTS AND CONVENTIONS FOR ENVIRONMENTAL PROTECTION

- 1971: RAMSAR Convention on Wetlands of International Importance especially as Waterfowl Habitat.
- 1972: Stockholm-United Nations Conference on the Human Environment.
  - o Outputs:
    - ❑ Stockholm Declaration of the UN Conference on the Human Environment: 26 principles, intended as a foundation for future developments in international environmental cooperation.
    - ❑ Action Plan for the Human Environment consisting of 109 recommendations for govt and intergovernmental action across the full range of environmental policy issues, ranging from species conservation, forests and atmospheric and marine pollution, to development policy, technology transfer and impact of environment on trade.
- 1973: International Convention for the Prevention of Pollution from Ships (MARPOL) (restricts release/dumping of oil, garbage, sewage, ballast waters, etc.).

- 1973: Convention on the International Trade of Endangered Species (CITES).
- 1974/84: First and Second UN Population Conferences: contentious events that, nonetheless, helped to focus attention and coordinate support for implementation of family planning programs in many countries.
- 1980: World Conservation Strategy. Coordinated by IUCN/WWF/UNEP, this was a major effort sponsored by non-government agencies to promote national conservation programs in LDCs.
- 1982: UN Conference on the Law of the Sea (UNCLOS). Established 200 mile territorial jurisdictions over coastal waters.
- 1985: Helsinki Protocol on the Reduction of Sulphur Emissions.
- 1985: Vienna Convention for the Protection of the Ozone Layer, established initial targets for gradual reductions in CFC production.
- 1987: Montreal Protocol (London Amendments, 1990) on Substances that Deplete the Ozone Layer, established specific time-tables for reductions and phase-out of CFC's by the turn-of-the-century, and established financial mechanism (Ozone Fund) to assist LDCs and former Soviet Bloc nations in phase-out.
- 1987: Our Common Future published (Report of the World Commission on Environment & Development/Brundtland Commission).
- 1988: Intergovernmental Panel on Climate Change formed by UNEP & WMO.
- 1989: Basel Convention on Control of Trans-boundary Movements of Hazardous Wastes and Their Disposal.
- 1992: Rio-United Nations Conference on Environment & Development. Outputs:
  - o **Rio Declaration**: statement of key principles for environment & development.
  - o **Agenda 21**: detailed list of recommendations

    Statement of Forest Principles (scaled down from Forest Convention).
  - o **Biodiversity Convention** (signed by 153 countries, but not US)

    Climate Change Convention
  - o **Global Environment Facility** (GEF) Established UN Commission on Sustainable Development to review progress of Rio efforts.
- 1994: **UN Convention to Combat Desertification** (particularly in Africa).
- 1994: **3rd International Population Conference, Cairo**, established broad consensus over need to make women's issues - health, education, employment, rights & empowerment - as central to concerns of family planning, fertility management and social development.
- 1997: **Kyoto Protocol** on the Reduction of Greenhouse Gases: Established first binding, numerical targets for reducing greenhouse gases.

- 2001: **UN-Stockholm Convention on Persistent Organic Pollutants** (DDT, PCBs, dioxin, furans)
- 2001: Bonn Framework Agreement for the Kyoto Protocol of the UN Convention on Climate Change.
- 2002: **Rio + 10**: UN World Summit for Sustainable Development, Johannesburg.
- 2005: **Kyoto Protocol** of 1997 comes into force.
- 2006: Asia-Pacific Partnership on Clean Development and Climate.
- 2007: **UNFCC-Bali Conference** on **Climate Change**: post-Kyoto road-map

Important national legislations related to environment

In order to deal with environmental and health related issues various laws, acts and rules have been enacted from time to time in India. A brief summary of such laws, acts and related rules is given below.

I. CENTRAL ENACTMENTS

(A) Water Pollution

- The Damodar Valley Corporation (Prevention of Pollution of Water) Regulation Act, 1948
- The Environment (Protection) Act, 1986
- The Indian Fisheries Act, 1897
- The Merchant Shipping (Amendment) Act, 1987
- The North India Canal and Drainage Act, 1873
- The River Boards Act, 1956
- The Water (Prevention and Control of Pollution) Act, 1974, amended in 1988
- The Water (Prevention and Control of Pollution) Cess Act, 1977

(B) Air Pollution

- The Air (Prevention and Control of Pollution) Act, 1981, amended in 1987
- The Environment (Protection) Act, 1986
- The Explosives Substances Act, 1908
- The Factories Act, 1948, amended in 1987
- The Indian Boiler's Act, 1923
- The Indian Explosives Act, 1884
- The Industries (Development and Regulation) Act, 1951
- The Inflammable Substances Act, 1952
- The Mines and Minerals (Regulation and Development) Act, 1947
- The Motor Vehicles Act, 1938, amended in 1988 and Rules, 1989

- The Oriental Gas Company Act, 1857
- The Petroleum Act, 1934 and Rules, 1979

(C) Hazardous Substances

- Dangerous Drugs Act, 1930
- The Drugs and Cosmetics Act, 1940
- The Environment (Protection) Act, 1986
- Explosive Act, 1884
- Explosive Substances Act, 1908
- The Factories Act, 1948, amended in 1987
- The Industries (Development and Regulation) Act, 1951
- Inflammable Substances Act, 1952
- The Insecticides Act, 1968
- The Poison Act, 1919
- The Prevention and Food Adulteration Act, 1954

II. STATE ENACTMENTS

(A) Water Pollution

- The Maharashtra Prevention of Water Pollution Act, 1969
- The Orissa River Pollution Prevention Act, 1953

(B) Smoke Control

- The Bengal Smoke Nuisance Act, 1905
- The Bombay Smoke Nuisance Act, 1912
- The Gujarat Smoke Nuisance Act, 1963

III. OTHER LEGISLATIONS

- Bhopal Gas Leak Disaster (Processing of Claims), Act, 1985
- Calcutta Municipal Corporation Act, 1980
- Code of Civil Procedure, 1908
- The Code of Criminal Procedure, 1973
- Delhi Municipal Corporation Act, 1957
- Gujrat Municipal Act, 1963
- Indian Easement Act, 1882
- The Indian Penal Code, 1960
- National Environment Tribunal Act, 1992

- The Monopolies and Restrictive Trade Practice Act, 1969
- Public Liability Insurance Act, 1991
- Sarai Act, 1867
- Workmen's Compensation Act, 1923

To ensure effective implementation, every act is followed by a set of rules and regulations prescribed under the provisions of that act. They have also been amended from time to time to suit and deal with the changed scenarios.

Water Pollution

Acts

1) The Water (Prevention and Control of Pollution) Act, 1974, amended 1988.
2) The Water (Prevention and Control of Pollution) Cess Act, 1977, amended 1992.
3) The Water (Prevention and Control of Pollution) Cess (Amendment) Act, 2003.

Rules

1) The Water (Prevention and Control of Pollution) Rules, 1975.
2) Central Board for the Prevention and Control of Water Pollution (Procedure for Transaction of Business) Rules, 1975 amended 1976.
3) The Water (Prevention and Control of Pollution) Cess Rules, 1978.

Air Pollution

Act

1) The Air (Prevention and Control of Pollution) Act, 1981, amended 1987.

Rules

1) The Air (Prevention and Control of Pollution) (Union Territories) Rules, 1983.
2) The Air (Prevention and Control of Pollution) Rules, 1982.

Environmental Protection

Act

1) The Environment (Protection) Act, 1986, amended 1991.

Rules

1) The Environment (Protection) Rules, 1986.

2) The Environment (Protection) (Second Amendment) Rules, 1998.
3) The Environment (Protection) (Second Amendment) Rules, 1999.
4) Environment (Siting for Industrial Projects) Rules, 1999
5) The Environment (Protection) (Amendment) Rules, 2001.
6) The Environment (Protection) (Second Amendment) Rules, 2002.
7) The Environment (Protection) (Third Amendment) Rules, 2002.
8) The Environment (Protection) (Fourth Amendment) Rules, 2002.
9) The Environment (Protection) (Amendment) Rules, 2003.
10) The Environment (Protection) (Second Amendment) Rules, 2004.
11) Environment (Protection) (First Amendment) Rules, 2006.
12) G.S.R.546(E), [30/08/2005]–Revised/New Environmental Standards for Pulp and Paper Industry, Guidelines for Disposal of Solid Waste, Drill Cuttings and Drilling Fluids for Offshore and Onshore Drilling Operation, Standards for Boilers using Agriculture Waste as Fuel and Guidelines for Pollution Control in Ginning Mills.

Notifications–Ecomarks Scheme of India

1) G.S.R.85(E), [20/2/1991]–The Scheme on Labeling of Environment Friendly Products (ECOMARK).
2) G.S.R.768(E), [24/8/1992]–The criteria for labeling Cosmetics as Environment Friendly Products.

Notifications–Environmental Clearance

1) S.O.60(E), [27/1/1994]–Restrictions & Prohibitions on the Expansion & Modernization of any activity or new projects unless Environmental Clearance has been accorded, amended 2001.
2) S.O.1087(E), [22/9/2003]–Amendments to S.O.60(E) dated 27/1/1994.
3) S.O.891(E), [4/8/2003]–Amendments to S.O.60(E) dated 27/1/1994.
4) S.O.506(E), [7/5/2003]–Amendments to S.O.60(E) dated 27/1/1994.
5) S.O.248(E), [28/2/2003]–Amendments to S.O.60(E) dated 27/1/1994.
6) S.O.801(E), [7/7/2004]–Amendments to S.O.60(E) dated 27/1/1994.

Hazardous Substances Management

Rules

1) The Batteries (Management and Handling) Rules, 2001.
2) The Municipal Solid Wastes (Management and Handling) Rules, 2000.
3) The Recycled Plastics Manufacture and Usage Rules, 1999.
4) The Recycled Plastics Manufacture and Usage (Amendment) Rules, 2003.

5) The Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996.
6) The Rules for the Manufacture, Use, Import, Export and Storage of Hazardous micro-organisms, Genetically engineered organisms or cells, 1989.
7) The Manufacture, Storage and import of Hazardous Chemical Rules, 1989.
8) The Manufacture, Storage and Import of Hazardous Chemical (Amendment) Rules, 2000.
9) The Hazardous Wastes (Management and Handling) Rules, 1989.
10) The Hazardous Wastes (Management and Handling) Amendment Rules, 2000.
11) The Hazardous Wastes (Management and Handling) Amendment Rules, 2003.
12) The Bio-Medical Waste (Management and Handling) Rules, 1998.
13) The Bio-Medical Waste (Management and Handling) (Amendment) Rules, 2003.

Noise Pollution

Rules

1) The Noise Pollution (Regulation and Control) Rules, 2000.
2) The Noise Pollution (Regulation and Control) (Amendment) Rules, 2000.
3) The Noise Pollution (Regulation and Control) (Amendment) Rules, 2002.

Rules relating to Noise Pollution notified under Environment (Protection) Rules, 1986 are as under:

1) The Environment (Protection) Amendment Rules, 2003.
2) The Environment (Protection) Fourth Amendment Rules, 2002.
3) The Environment (Protection) Second Amendment Rules, 2002.
4) The Environment (Protection) Amendment Rules, 2001.
5) The Environment (Protection) Second Amendment Rules, 1999.
6) The Environment (Protection) Second Amendment Rules, 1998.

National Environment Appellate Authority

Act

1) The National Environment Appellate Authority Act, 1997.

National Environment Tribunal

Act

1) The National Environment Tribunal Act, 1995.

RECAPS AND PRACTICES

Walk and Talk

(Facts in brief)

- Environmental protection is a global issue and requires legal framework to guide nations and individuals towards a safe and sustainable future.
- Stohkholm Declaration (1972), Rio Declaration (1992), Kyoto Protocol (1997), Johansberg Declaration (2002), etc. are some of the international agreements which paved way for world nations to formulate laws for environmental protection.
- India has always been an important signatory to most of environmental protection agreements held at international fora.
- Indian constitution has ample scope to allow legislative measures for environmental protection in the country.
- Article 253 of Indian constitution empowers the parliament to make any law for implementing any decisions made at an international conference or association.
- Article 51(g) of the constitution states that, "it shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife."
- In the 42^{nd} amendment of Indian constitution a new directive principle in article 48-A was added. It states that the state shall endeavour to protect and improve the environment.
- Wildlife protection act aimed at conservation of endangered wildlife species by regulating and preventing hunting, poaching, smuggling, etc of wildlife including plants and animals. It provides for creation of protected areas and penalties for violators.
- Several conservation projects were launched for conservation of individual endangered species in India under the provisions of Wildlife Protection Act, 1972. They include
    - Save Lion Project, 1972
    - Project Tiger, 1973
    - Project Crocodile, 1974
    - Project to save Brown Antlerered Deer, 1981
- Water and air pollution control acts aimed at prevention of environmental pollution. These acts authorise the government to establish research laboratories and special boards for controlling pollution.
- Environmental ethics is relatively a new discourse that provides guidance on ethical basis for environmental protection in modern context

Practice and Prepare

(Self Tests)

(Multiple choice objective type questions)

1. The Forest Conservation Act, 1980 was amended in
   a. 1981 b. 1987
   c. 2001 d. 1988 **Ans. d**
2. Wildlife Protection Act, 1972 authorises the central government to appoint
   a. Director of wildlife preservation
   b. Assistat Director of wildlife preservation
   c. Other officers of wildlife preservation
   d. All of the above **Ans. d**
3. Under Wildlife Protection Act 1972 ,the state government may appoint
   a. Chief Wildlife Warden
   b. Minister of Forest Conservation
   c. Divisional Forest Officer
   d. None of the above **Ans. a**
4. Which section of Wildlife Protection Act 1972 deals with declaration/creation of a wildlife sanctuary
   a. Section 9 b. Section 10
   c. Section 16 d. Section 18 **Ans. d**
5. Stockholm Declaration was signed in
   a. 1970 b. 1972
   c. 1980 d. 1992 **Ans. b**
6. The Earth Summit or UN Conference on Environment and Development (UNCED)of 1992 held at
   a. Kyoto b. Delhi
   c. Rio de Janero (Brazil) d. Johansberg **Ans. c**
7. Rio de Janero Declaration was signed by more than
   a. 100 countries b. 500 countries
   c. 1200 countries d. 150 countries **Ans. d**
8. 'Every creature has right to live' is part of
   a. Biodiversity Convention b. Environmental ethics
   c. Forest conservation laws d. All of the above **Ans. b**

9. Which section of Air (prevention and Control) Act1981 delas with emission standards for automobiles
   a. Section 01 b. Section 05
   c. Section 20 d. Section **Ans. c**
10. Constitution of Central Zoo Authority was ensured under
    a. Forest Protection Act 1921 b. Wildlife Protection Act 1972
    c. Environmental Protection Act 1986 d. None of the above **Ans. b**
11. Which section/s of Air (Prevention and Control) of Pollution Act 1981 deals with penalties for the defaulters
    a. Section 21 b. Sections 21 and 22
    c. Sections 30 and 31 d. Section 35 **Ans. b**
12. Functions of Central and State Pollution Control Boards are defined/described in
    a. Forest Protection Act 1981
    b. Water (Prevention and Control) of Pollution Act 1972
    c. Air (Prevention and Control) of Pollution Act 1981
    d. None of the above

    Ans. b. Water Prevention and Control) of Pollution Act 1972 (later also covered under Air (Prevention and Control) of Pollution Act 1981)
13. Environmental Protection Act 1986 was enacted on
    a. May 23, 1986 b. January 18, 1986
    c. August 12, 1986 d. December 19, 1986

    Ans. a. May 23, 1986 (and was implemented on November19, 1986)
14. Environmental Protection Act 1986 was amended in
    a. 1988 b. 1990
    c. 1994 d. None of the above **Ans. c**
15. Under Air (Prevention and Control) of Pollution Act 1981
    a. New central and state pollution control boards (CPCB & SPCB)were constituted
    b. Additional functions were assigned to the existing CPCB & SPCB
    c. None of the above
    d. Both (a) and (b)

    Ans. b. Additional functions were assigned to the existing CPCB & SPCB in addition to those already assigned under Water (Prevention and Control) of Pollution Act 1972

16. Hazardous Wastes (Mangement and Handling) Rules 1989 were made under which of the following Acts
    a. Environmental Protection Act 1986
    b. Air (Prevention and Control) of Pollution Act 1981
    c. Water (Prevention and Control) of Pollution Act 1972
    d. None of the above **Ans. a**
17. Which among the following is not a drawback in environmental legislation in India
    a. Lighter penalties for defenders
    b. Litigation is expensive and slow
    c. Separate courts for environmental issues
    d. All of the above

    Ans. c. Separate courts for environmental issues(which do not exist)
18. Wildlife Protection Act 1972
    a. Defines wildlife related terms
    b. Provides for the establishment of Wildlife Advisory Boards
    c. Imposes ban on the trade of scheduled animals
    d. All of the above **Ans. d**
19. Captive breeding programmes for endangered animals are executed under
    a. Forest Protection Act 1980
    b. Air (Prevention and Control) of Pollution Act 1981
    c. Wildlife Protection Act 1972
    d. None of the above **Ans. c**
20. Which type of forests are covered for protection under Forest Protection Act 1980
    a. Himalayan and Sub-Himalayan forests
    b. Tropical rain forests of Kerala
    c. Temperate deciduous forests of J&K
    d. All of the above **Ans. d**
21. Which is not the role of Central Pollution Control Board
    a. It advices central government to control water pollution
    b. It coordinates the activities of the state pollution control boards
    c. It lays down standards for water quality parameters
    d. It establishes laboratories for soil testing

    Ans. d. It actually establishes laboritories for research in pollution related matters

22. Noise pollution was inserted in which of the following Acts and when
    a. Air (Prevention and Control) of Pollution Act in 1987
    b. Was part of Air Pollution Act since 1981
    c. Environmental Protection Act in 1987
    d. None of the above

Ans. a. It was inserted in Air (Prevention and Control) of Pollution Act of 1981 through an amendment in 1987.

Chapter 8

Disasters and Their Management

We never know the worth of water till the well is dry

Thomas Fuller

OBJECTIVES

✓ We will endeavour to learn in this unit about:
  - o Disaster and its management
    - ❑ Earthquakes
    - ❑ Floods
    - ❑ Cyclones
    - ❑ Landslides
  - o Resettlement and rehabilitation of people, its problems and concerns
  - o Wasteland reclamation

CHAPTER 8 DISASTERS AND THEIR MANAGEMENT

Life on Earth is at the ever-increasing risk of being wiped out by a disaster we have not yet thought of.

Stephen Hawking

ABSTRACT

Disasters are natural as well as manmade. Natural disasters are the occurencences beyond man's control but the damages caused by these disastrous events can be minimized by proper planning and preventive measures. Disaster is a catastrophic situation that leads to sudden disruption of normal life of a society, causing damage to life and property to such an extent that normal social and economic values available are inadequate to restore normalcy after a disaster. In such a situation extra-ordinary emergency interventions are required to save and preserve lives and the environment. "Disaster management" refers to a continuous and integrated process of planning, organising, coordinating and implementing measures which are necessary or expedient for prevention, mitigation, capacity-building, preparedness or prompt response in in order to avoid or minimize the damages due to disastrous situations.

INTRODUCTION

A 'disaster' is an event or series of events, which gives rise to casualties and damage or loss of properties, infrastructure, environment, essential services or means of livelihood on such a scale which is beyond the normal capacity of the affected community to cope with. Disaster is also sometimes described as a "catastrophic situation in which the normal pattern of life or eco-system has been disrupted and extra-ordinary emergency interventions are required to save and preserve lives and or the environment".

The United Nations defines disaster as "the occurrence of sudden or major misfortune which disrupts the basic fabric and normal functioning of the society or community". A disaster is an event of nature or man-made that leads to sudden disruption of normal life of a society, causing damage to life and property to such an extent that normal social and economic values available are inadequate to restore normalcy after a disaster." A disaster is a sudden, calamitous event that seriously disrupts the functioning of a community or society and causes human, material, and economic or environmental losses that exceed the community's or society's ability to cope using its own resources. Though often caused by nature, disasters can have human origins.

As per the Disaster Management Act 2005, a disaster is defined as "a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or man-made cause, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of property, or damage to, or degradation of, environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area".

Geological processes like earthquakes, volcanoes, floods and landslides are normal natural events which have resulted in the formation of the earth that we have today. They are, however, disastrous in their impacts when they affect human settlements. Human societies have witnessed a large number of such natural hazards in different parts of the world and have tried to learn to control them or minimize the losses due to them to some extent. Though most of the disasters are caused by natural factors human interventions in his environment and changes in the patterns of land use often increase the intensity and frequency of natural disasters.

DETAILS AND DISCUSSIONS

The entire Indian subcontinent is very vulnerable to natural disasters like droughts, floods, cyclones, earthquakes, landslides, avalanches and forest fires. Among the 36 states and Union territories in the country, 22 are prone to disasters. Among all the disasters that occur in our country, floods are the most frequently occurring natural disasters, due to the irregularities of the Indian monsoon. About 75 percent of the annual rainfall in India is concentrated in three to four months of the monsoon season. As a result there is a very heavy discharge from the rivers during this period causing widespread floods. Approximately 40 million hectares of land in the country has been identified as being prone to floods. Major floods are mainly caused in the Ganga-Brahmaputra-Meghna basin which carries60 percent of the total river flow of our country. India has a long coastline of 5700 kms, which isexposed to tropical cyclones arising in the Bay of Bengal and the Arabian Sea. The Indian Ocean is one of the six major cyclone prone regions of the world. In India, cyclones occur usually betweenApril and May and also between October and December. The eastern coastline is more prone to cyclones as it is hit by about 80 percent of the total cyclones generated in the region.. Drought is a significant environmental problem as it is caused by a lower than average rainfall over a long period of time. Droughts are a perennial feature in some of the Indian states. Sixteen percent of the country's total area is drought prone. Most of the drought prone areas lie in the arid and semi-arid areas of the country. Earthquakes are considered to be one of the most destructive natural hazards. The impact of this phenomenon occurs with so little or no warning that it is almost impossible to make reparations against damages and collapse of buildings. About 50 to 60 percent of India is vulnerable to seismic activity of varying intensities. Most of the vulnerable areas are located in the Himalayan and sub-Himalayan regions. Our state is among the most sensitive regions in this regard.

8.1. DISASTER MANAGEMENT

Natural disasters are actually a part and parcel of the environment we live in. However destruction from natural hazards can be minimized by the presence of a well functioning warning system combined with preparedness on part of the community that will be affected. Till very recently the approach towards dealing with natural disasters has been post disaster management involving problems such as evacuation, warnings, communications, search and rescue, fire-fighting, medical and psychiatric assistance, provision of relief, shelter, etc. After the initial trauma and the occurrence of the natural disaster is over and reconstruction and rehabilitation is done by people, NGOs and the Government, its memories are relegated to history.Thus though traditionally disaster management consisted primarily of reactive mechanisms, the past few years have witnessed a gradual shift towards a more proactive, mitigation based approach.

As per Disaster Management Act, 2005, "disaster management" means a continuous and integrated process of planning, organising, coordinating and implementing measures which are necessary or expedient for:

(i) Prevention of danger or threat of any disaster;

(ii) Mitigation or reduction of risk of any disaster or its severity or consequences;

(iii) Capacity-building;

(iv) Preparedness to deal with any disaster;

(v) Prompt response to any threatening disaster situation or disaster;

(vi) Assessing the severity or magnitude of effects of any disaster; evacuation, rescue and relief;

(vii) Rehabilitation and reconstruction;

Disaster Management can be defined as the organization and management of resources and responsibilities for dealing with all humanitarian aspects of emergencies, in particular, preparedness, response and recovery in order to lessen the impact of disasters. Disaster management includes administrative and operational activities that involve

- Prevention
- Mitigation
- Preparedness
- Response
- Recovery
- Rehabilitation

Modern disaster management is not merely post disaster activities but includes pre-disaster planning and preparedness activities, organizational planning, training, information management, public relations and many other fields.

8.1.1. Disaster Management Cycle

Disaster management is a multidisciplinary area in which a wide range of issues that range from forecasting, warning, evacuation, search and rescue, relief, reconstruction and

Fig. 5..1 Disaster management cycle. (National disaster management institute of india website)

rehabilitation are included. It is also multi-sectoral as it involves administrators, scientists, planners, volunteers and communities. Since their role and activities are complementary as well as supplementary to each other there is a critical need for coordinating these activities. In order to transfer the benefits of scientific research and development to the communities, links must be developed between scientific communities and the field agencies.

Disaster management consists of phased sequences of action or a continuum which can be represented as a disaster management cycle.

There are three key phases of activity within disaster management:

- **Pre – Disaster**: Before a disaster to reduce the potential for human, material or environmental losses caused by hazards and to ensure that these losses are minimized when the disaster actually strikes.
- **During Disaster**: It is to ensure that the needs and provisions of victims are met to alleviate and minimize suffering.
- **Post Disaster**: After a disaster to achieve rapid and durable recovery which does not reproduce the original vulnerable conditions

A. Pre – Disaster Phase

I. **Prevention and Mitigation:** Mitigation means lessening the negative impact of the natural hazards. It is defined as sustained action taken to reduce long term vulnerability of human life and property to natural hazards. While the preparatory, response and the recovery phases of emergency management relate to specific events, mitigation activities have the potential to produce repetitive benefits over time. The main elements of a mitigation strategy are as follows:

   1. **Risk assessment and Vulnerability analysis**: This involves identification of hot spot areas of prime concern, collection of information on past natural hazards, information of the natural ecosystems and information on the population and infrastructure. Once this information is collected a risk assessment should be done to determine the frequency, intensity, impact and the time taken to return to normalcy after the disaster. The assessment of risk and vulnerabilities will need to be revised periodically. A regular mechanism will therefore have to be established for this. The use of Geographical Information Systems (GIS) a computer program can be a valuable tool in this process as the primary data can be easily updated and the corresponding assessments can be made.
   2. **Applied research and technology transfer**: There is a need to establish or upgrade observation equipment and networks, monitor the hazards properly, improve the quality of forecasting and warning, disseminate information quickly through the warning systems and undertake disaster simulation exercises.

Thus space technologies such as remote sensing, satellite communications and Global Positioning Systems have a very important role to play. Government organizations like ISRO (Indian Space Research Organization) can play a vital role in this regard. Similarly Government organizations the National Building Research Organization, the Meteorological Department, Irrigation Department, etc. can undertake applied research for devising locale specific mitigation strategies in collaboration with educational institutions or Universities. Such steps could lead to the formulation of locale specific mitigation measures. A combination of scientific knowledge and expertise with the community based mitigation measures would not only enhance the database but would also form the basis of a successful mitigation strategy.

3. **Public awareness and training**: One of the most critical components of a mitigation strategy is the training to be imparted to the officials and staff of the various departments involved at the state and the district level. This enables sharing of information and methodology. The success of a mitigation strategy will depend to a large extent on the inter-sectional, inter-departmental coordination and efficient team work. Thus a training program that is designed after assessment of gaps in knowledge, skills and attitude with respect to the various tasks that need to be undertaken is a vital component.
4. **Institutional mechanisms**: The most important need at the National level is to strengthen or develop the capacity to undertake disaster mitigation strategies. There is a need to emphasize on proactive and pre-disaster measures rather than post disaster response. It is thus essential to have a permanent administrative structure which can monitor the developmental activities across departments and provides suggestions for necessary mitigation measures. Professionals like architects, structural engineers, doctors, chemical engineers who are involved with management of hazardous chemicals can be asked to form groups that can design specific mitigation measures. Incentives and resources for mitigation: To a very large extent the success of mitigation programs will depend upon the availability of continued funding. There is thus a need to develop mechanisms to provide stable sources of funding for all mitigation programs. This will include incentives for relocation of commercial and residential activities outside the disaster prone areas. Housing finance companies should make it mandatory for structures in such hazard prone areas to follow special building specifications. The introduction of disaster linked insurance should be explored and should cover not only life but also household goods, cattle, structures and crops.
5. **Land use planning and regulations**: Long term disaster reduction efforts should aim at promoting appropriate land-use in the disaster prone areas. Separation of industrial areas from residential areas, maintaining wetlands as buffer zones for floods, creation of public awareness of proper land practices and formation of land-use policies for long term sustainable development is imperative.

6. **Hazard resistant design and construction**: In areas that are prone to disasters protection can be enhanced by careful selection of sites and the way the buildings are built. Thus it is essential to promote the knowledge of disaster resistant construction techniques and practices among engineers, architects and technical personnel.

II. **Preparedness**: The process embraces measures that enable governments, communities and individuals to respond rapidly to disaster situations to cope with them effectively. Preparedness includes for example, the formulation of viable emergency plans, the development of warning systems, the maintenance of inventories, public awareness and education and the training of personnel. It may also embrace search and rescue measures as well as evacuation plans for areas that may be „at risk from a recurring disaster. Preparedness planning needs to be supported by appropriate rules and regulations with clear allocation of responsibilities and budgetary provisions.

III. **Early Warning**: This is the process of monitoring the situation in communities or areas known to be vulnerable to slow onset hazards, and passing the knowledge of the pending hazard to people in harm s way. To be effective, warnings must be related to mass education and training of the population who know what actions they must take when warned.

B. During disaster Phase

This refers to the first stage response to any calamity, which include for examples such as setting up control rooms, putting the contingency plan in action, issue warning, action for evacuation, taking people to safer areas, rendering medical aid to the needy etc., simultaneously rendering relief to the homeless, food, drinking water, clothing etc. to the needy, restoration of communication, disbursement of assistance in cash or kind. The emergency relief activities undertaken during and immediately following a disaster, which includes immediate relief, rescue, and the damage needs assessment and debris clearance.

C. Post- disaster Phase

1. **Recovery**: Recovery is used to describe the activities that encompass the three overlapping phases of emergency relief, rehabilitation and reconstruction. Rehabilitation: Rehabilitation includes the provision of temporary public utilities and housing as interim measures to assist long-term recovery.

2. **Reconstruction**: Reconstruction attempts to return communities to improved pre-disaster functioning. It includes such as the replacement of buildings; infrastructure and lifeline facilities so that long-term development prospects are enhanced rather than reproducing the same conditions, which made an area or population vulnerable in the first place.

3. **Development**: In an evolving economy, the development process is an ongoing activity. Long-term prevention/disaster reduction measures for examples like construction of embankments against flooding, irrigation facilities as drought proofing measures, increasing plant cover to reduce the occurrences of landslides, land use planning, construction of houses capable of withstanding the onslaught of heavy rain/ wind speed and shocks of earthquakes are some of the activities that can be taken up as part of the development plan.

8.2. NATURAL DISASTERS AND THEIR MANAGEMENT: COMMON EXAMPLES

8.2.1. Earthquakes

Earthquakes occur due to sudden movements of earth's surface caused due to endogenic disturbances deep inside earth's crust.

Causes of earthquake

Natural causes of earthquakes can be summarised as below:

1. **Volcanic activity**: volcanic eruptions are considered to be one of the major causes of earthquakes. In fact volcanic eruption and seismic events are closely related and they may become cause and effect for each other. Earthquakes follow each volcanic eruption and likewise many of the severe earthquakes too cause volcanic eruptions.
2. **Faulting and Elastic Rebound Theory:** The horizontal and vertical movements caused by endogenic forces(forces working deep inside the earth crust) result in the formation of faults and folds which in turn cause isostatic disequilibria in the crystal rocks and ultimately causes earthquakes of varying magnitudes depending on the nature and magnitude of dislocation of rock blocks caused by faulting and folding.
3. **Plate Tectonic Theory:** The earth is composed of solid and moving plates having either continental crust or oceanic crust or even both continental oceanic crusts. The earth's crust consists of 6 major plates , namely Eurasian plate, American plate, African plate, Indian plate, Pacific plate and Antarctic plate and 20 minor plates. These plates constantly remain moving in relation to each other. All sorts of disequilibria are caused due to tectonic plate motions and consequently earthquakes of varying magnitudes are caused.
4. **Manmade causes:** Anthropogenic activities can also cause or enhance the frequency of earthquakes. Three such activities identified are:
   (a) Impoundment of huge quantities of water in the lake behind a big dam.
   (b) Underground nuclear testing.
   (c) Deep well disposal of liquid waste.

The place where the earthquake originates inside the earth is called Focus and the point just above it on the earth's surface at which the first movement occurs during an earthquake is called the epicenter. During an earthquake huge energy is released in the form of seismic waves which are of following three types

1. Primary waves(P-waves)
2. Secondary waves and (S-waves)
3. tertiary waves(L-waves)

Seismograph is the instrument which helps in recording and studying of these waves.

The severity of an earthquake is generally measured by its magnitude on Richter Scale(having scale from 0 to 9), as shown below:

Richter Scale Severity of earthquake

Less than 4	Insignificant
4 - 4.9	Minor
5 - 5.9	Damaging
6 - 6.9	Destructive
7 - 7.9	Major
More than 8	Great

The largest earthquake ever recorded occurred on May 22, 1960 in Chile with the estimated magnitude of 9.5 on Richter Scale, affecting 90,000 square miles and killing 6,000 people.

The devastating earthquake which hit Bhuj Town in Gujarat had caused massive damage, killing 20,000-30,000 people and leaving many injured. It had an energy equivalent to a 5.3 megaton hydrogen bomb. Earthquake-generated water waves called tsunamis can severely affect coastal areas. These giant sea swells can move at a speed upto1000 Km/hr or even faster. While approaching the sea shore they may often reach 15 m or sometimes upto 65 m in height and cause massive devastation in coastal areas. In China such waves killed 8,30,000 people in 1556 and 50,000 in 1976.

Mitigative measures

Man can do nothing to reduce the intensity or frequency of earthquakes. However, damage to property and life can be prevented by constructing earthquake-resistant buildings in the earthquake prone zones. For this, the structures are heavily reinforced, weak spots are strategically placed in the building that can absorb vibrations from the rest of the building, pads or floats are placed beneath the building on which it can shift harmlessly when ground moves during the event of an earthquake. Wooden houses are preferred in earthquake prone areas.

8.2.2. Floods

Generally the stream channels accommodate some maximum stream flow. However, due to heavy rains or sudden snow melt the quantity of water in streams exceeds their capacity and water overflows the banks and causes inundation of the surrounding land. This situation is called flood.

Types of floods

Floods can be classified into three categories as under:

(i) River floods: Due to heavy rains over large catchments areas rivers and streams get overcharged especially in the mountainous regions. The floods take place in river systems with tributaries that may drain into large geographic areas and encompass many independent river basins.

(ii) Coastal floods: Floods in coastal areas are associated with tropical cyclones/ harsh winds arising at the ocean surface.

Sea and ocean's water floods the inland coasts affecting large tracts in the adjoinings. Ocean tides, storm surges or tsunamis play a definite role. Prolonged and indefinite rains in the rainy season marked from June-September results in extreme flood in coastal river basins.

(iii) Flash floods: These floods occur as a result of torrential downpour, particularly if the catchments slope is unable to absorb and hold a significant part of water. Other causes of flash floods include dam failure, sudden break up of glaciers etc. These offer potential threats in the areas where the terrain is steep, surface runoff is high, water flows through canyons and where severe rainstorms are likely.

Effects of Floods

Floods generally don't damage property or cause casualities to an extent as done by other natural disasters. However, it causes a great economic loss and health related problems due to widespread contamination. Virtually anything the flood water touches gets contaminated, posing serious threat to health due to outbreak of epidemics.

1. Floods cause damages to the residential and commercial buildings. They are dangerous for villages lying in the coastal areas as they sweep away everything, which comes into their path. In mountainous areas floods cause landslides and life and property losses.
2. Local people, cattle, animals and vegetation suffer a great loss of life and property. Deaths are reported to be from drowning.
3. Fresh water supplies are destroyed and contaminated hence the areas falling under its impact bear a great risk of suffering from water borne diseases.
4. The destruction of food and fodder crops result in acute food shortage.
5. Floods also make soil infertile, as the topsoil is lost due to their erosional activity.

Human activities have been the main causes for increasing the severity and frequency of floods. Construction of roads, parking space and buildings that cover the earth.s surface hardly allows infiltration of water into the soil and speeds up the runoff. Clearing of forests for agriculture has also increased the severity of floods. In India, Uttar Pradesh is considered to be amongst the worst flood hit states of the country. It has nearly 20% of the total 40 million hectares of flood prone zone of the country.

Flood Problem in India

The nature of flood problem varies from one river system to another. Two great river systems are discussed below considering the flood problems in India:

Brahmputra River: The main problem of flooding in the northeastern region arises from the Brahmaputra river and its tributaries. The river in monsoon season overflows its banks and causes a great damage to life and property both. Several times it has affected Kaziranga wildlife sanctuary where rhinoceros population died due to rising floods. In recent years, the erosion along the banks of the Brahmputra has assumed serious proportions. The rivers also carry considerable amount of silt and have a tendency to change its course.

Ganga River System: In this region the northern tributaries of the Ganga, namely the Rapti, the Sharada,the Ghaghra and the Gandak cause extensive flooding along their banks. Drainage congestion is confined to the northwestern parts of U.P., Meerut, Mathura and Agra suffers the most. Bihar suffers a considerable amount of damage due to the flooding of the Burhi Gandak, the Baghirati, the Kamla Balan, the Kosi and the Mahananda. In addition to the crop submergence the area experiences traffic dislocation also. sIn the Bengal region Baghirati, the Ajoy and the Damodar cause extensive flooding. Here the tidal effect of Bay of Bengal also plays a role in flooding. In Delhi and Haryana it is the Yamuna, the biggest tributary of the Ganga, which causes a marginal amount of flooding. Most of these flooding regions suffer from inadequate channel capacity as well as regulation of river water flow in these channels. (Crtsy: Singh, 2006)

Mitigative Measure

To check the floods, efforts need to be made to restore wetlands, replace ground cover on water-courses, build check-dams on small streams, move buildings off the flood plains etc. Instead of raising buildings on flood plains, it is suggested that floodplains should be used for wildlife habitat, parks, recreational areas and other uses, which are not susceptible to flood damage. Some important steps to be taken for minimizing the occurrence or effects of floods are:

1. Depth and width of the riverbed could be increased as its capacity to carry larger loads increases manifold and thus reduce the area of the flood plain.
2. A network of canals can be established from the river systems, which generally leads to floods. This would also benefit the agricultural economy/ section. Care must be taken in the design and construction because of the possible environmental impact and necessary safety features.
3. Reservoirs should be made for storing floodwater and releasing them at manageable rates. This would require careful engineering. Dams and reservoirs would further lead to generation of resources.

4. Newly constructed residential as well commercial buildings should have foundations, which are strong enough to respond to flood conditions.
5. Rivers and streambeds should be stabilized with stone, masonry or vegetation at the banks. This should strictly be followed where rivers pass through cities, especially near bridges.

On an average, every year one major disaster hits India, causing huge economic losses and loss of human life. There is a need for systematic studies and strategies to evolve a Disaster Management Plan for our country. The initial response to flooding should include Search and Rescue operations, water provision,

Medical assistance, Disaster epidemiological surveillance assessment, food and and temporary shelter.

The secondary response should include reconstruction of houses, equipment and tools, creation of employment,

8.2.3 Landslides

Landslide occurs when coherent rock of soil masses move down slope due to gravitational pull. Slow landslips don.t cause much worry but sudden rockslides and mudslides are dangerous. Water and vegetation influence landslides. Chemical action of water gradually cause chemical weathering of rocks making them prone to landslides. Vegetation consolidates the slope material, provides cohesion by its root system and also retards the flow of water and its erosion capacity.

However, this can be masked by many other exerting factors like:

(i) Earthquakes, vibrations etc.

(ii) Disturbances in resistant rock overlying rock of low resistance.

(iii) Saturation of the unconsolidated sediments with water.

(iv) Unconsolidated sediments exposed due to logging, road or house building.

Landslides are governed by the forces which tend to pull the earth material down slope (move in case of slopes with steeper slip plane) and resisting forces which tend to resist such movements. It is difficult to control landslides. These can be minimized by stabilizing the slope by:

(i) Draining the surface and subsurface water.

(ii) Providing slope support like gabions (wired stone blocks)

(iii) Concrete support at the base of a slope.

8.2.4. Cyclones

Cyclones are the result of atmospheric disturbances on land. They are linked with the temperature and pressure changes in an area. A mass of air with specific physical characteristics moves and meets another air mass and results in the deveoplement of condition called cyclone which moves from an area to the other. Under certain atmospheric conditions centers of low pressure are formed in an area which is surrounded by increasing pressure outward. closed air circulation from outside towards the central low pressure takes place with tremendous speed and cause damage to life and property. This air blows inward in anticlockwise in northern hemisphere and clockwise in southern hemisphere. These cyclones vary in shape from circular to elletical or sometimes V shaped. They are spread over wide areas and also moves from one region to another. From their locational viewpoint cyclones are classified into two main types

- **Tropical cyclones.**
- **Temperate cyclone**

Tropical cyclones are common phenomena in the tropical coastal regions. One of the factors responsible for tropical cyclones is the sea surface temperature above 26°C. These cyclones move like a spinning top at the speed of 10-30 Km per hour. They can last for a week or so and have a diameter varying between100 to 1500 Km. Since in the western parts of the main ocean no cold currents exist, tropical cyclones originate there. Tropical cyclones are called hurricanes in the Atlantic, Caribbean and north eastern Pacific, typhoons in the western Pacific, willy williesin in Australia and cyclones in the Indian

Tropical cyclones are very severe disastrous natural hazards which inflict heavy loss to human lives and property in terms of destruction of buildings, transport systems, water and power supply systems, disruption of communication system, destruction of standing agricultural crops, domestic and wild animals, natural vegetation, private and public institutions etc.

2014 Flood havoc in Jammu and Kashmir

During September 2014, the state of Jammu and Kashmir as also some adjoining areas in Pakistan witnessed disastrous floods caused by torrential rainfall. Large number of people particularly in the valley of Kashmir and the hilly regions of PirPanjal suffered due to floods and landslides. As per media reports hundreds of people died and many others were displaced besides great losses of property.

The Jammu and Kashmir state and adjoining areas received heavy rainfall from 2 September 2014 onwards, during last stage of monsoon in India. This triggered flooding and landslides in the region. On 5 September, the Jhelum River in Srinagar was reported to be flowing at 22.40 feet (6.83 m) which was 4.40 feet (1.34 m) above the danger mark and at 33 feet (10 m) at Sangam in Anantnag district above the danger mark. The discharge rate in the river was recorded as 70000 m^3/s against the normal discharge of 25000 m^3/s. The Chenab River was also reported to flow above the danger mark by which hundreds of villages were affected in in jammu region and in Pakistan. These rivers flooded into the streets causing heavy casualties and loss of property. According to the Home Ministry of India, several thousand villages across the state had been hit and 390 villages had been completely submerged. In actual figures 2600 villages were reported to be affected in Jammu and Kashmir, out of which 390 villages in Kashmir were completely submerged. 1225 villages were partially affected and 1000 villages were affected in Jammu Division. Many parts of Srinagar, including the Border Security Force (BSF) HQ in Sanant Nagar & Army cantonment in Badami Bagh, were inundated, and vital roads were submerged, by the floods. In the Jammu Division, landslides triggered by heavy rainfall had damaged roads, dozens of bridges, buildings and crops. Vehicular traffic had been stopped on the Jammu-Pathankot highway. Katra-bound trains were halted. Haj flights scheduled up to 12 September, were postponed. The Jammu-Pathankot national highway was opened on September 8, after the water level receded. Srinagar-Leh Highway reopened for traffic on 9 September. Landslides hit hilly villages in Rajouri, Poonch and Doda districts. Many houses collapsed in Thannamandi, Kotranka, Badhal, Khawas, and other rural areas. 50 bridges were reported to have been damaged across the state. The preliminary assessment of damages to property was estimated between INR 5000 cr to INR 6000 cr.

Management: It is difficult to stop the recurrence of cyclones. Some long term defence measures can help to protect us from devastation. Such measures include, planting more trees on the coastal belt, construction of dams, dykes, embankments, storm shelter, windbreaks, proper drainage and wide roads for quick evacuation.

Nepal Earthquake, 2015

An earthquake of as high as 7.8 magnitude on Richter scaleo ccurred on 25 April 2015 at 11:56 in Nepal. Its epicenter was the village of Barpak, Gorkha district, and it was the most powerful disaster to strike Nepal since the 1934 Nepal-Bihar earthquake. The devastating event killed more than 7000 people and rendered thousands of more injured. Hundreds of thousands of people were made homeless with entire villages flattened, across many districts of Nepal. Hundreds of others are still considered missing as per media reports and official estimates.

Centuries-old buildings were destroyed at UNESCO World Heritage sites in the Kathmandu Valley, including some at the Kathmandu Durbar Square, the Patan Durbar Square and the Bhaktapur Durbar Square. Continued aftershocks occurred throughout Nepal, with one shock reaching a magnitude of 6.7 on 26 April.

Some casualties were also reported in the adjoining areas of India, China, and Bangladesh. The earthquake triggered an avalanche on Mount Everest, killing at least 19 people.

According to the USGS, the temblor was caused by a sudden thrust, or release of built-up stress, along the major fault line where the Indian Plate, carrying India, is slowly diving underneath the Eurasian Plate, carrying much of Europe and Asia. Kathmandu, situated on a block of crust approximately 120 km wide and 60 km long, reportedly shifted 3 m to the south in just 30 seconds.

8.3. RESETTLEMENT AND REHABILITATION OF AFFECTED PEOPLE

It refers to the resettlement of the people displaced from their original place of residence due to some natural disasters or because of any developmental projects. It involves a proper planning and a multitude of activities towards providing displaced population a new home, social securities and basic amenties. It consists of identification of problem, assessment of displaced populations, demarcation of new site, construction of facilities and developmental planning of the colonized area.

Causes and concerns

Natural disasters often cause huge losses of life and property. It becomes extremely difficult for the sufferers to deal with the situation as most of them happen to be poor of the poorest. It becomes inevitable for the governmental agencies to help them revive their life and sustenance. In such cases they are helped to settle preferably on their original place. Concerned agencies work in a coordinated manner for their rehabilitation and reconstruct the damaged infrastructure and facilities. In case of certain developmental projects people are evacuated from their residential areas and agencies arrange for their resettlement on some other place earmarked for the purpose. The rehabilitation involves a suitable policy and proper planning as it is actually the involuntary displacement of human population which is always very traumatic. Sufferings of the people affected by such migrations can't be quantified or compensated. Developmental projects are aimed at human welfare but during their execution large scale environmental degradation is caused and the native people are deprived of their homeland. It not only causes socioeconomic problems for them but also results in psychological issues and health problems. Various causes under the category of developmental projects which displace local inhabitants include the following

- Displacement due to dams. The big river valley projects constructed for electric power generation and irrigation require a huge landmass to dam water. For this locals are evacuated even from the adjoining areas. India is one of countries in the world leading in big dam construction and in the last 50 years more than 20 million people are estimated to have been directly or indirectly affected by these dams. more than 20,000 people residing in about 250 villages were displaced due to the Hirakund Dam. The Bhakra Nangal Dam was constructed during 1950s and till now not even half of the displaced persons have been rehabilitated properly. Same is the case with Tehri Dam. Sardar Sarovar Project which consists of building 30 big, 135 medium and 3000 minor dams on the Narmada river and its tributaries is estimated to affect three lakh people of 573.
- Displacement due to Mining: the areas from where mining is done are cleared of forest cover. Roads are constructed in the entire area. Natives are shifted from the region but their rehabilitation is hardly completed in proper way.

- Displacement due to Creation of National Parks and Wildlife Sanctuaries: Declaring an area as protected for conservation purposes is a good step but it too results in the displacement of the tribals and the forest dwellers from the core zones.
- Laying of super highways, railway line or other connectivity tools
- Construction of governmental buildings, compounds or residential towns

Solution

Y K Singh (2006) suggests following points to be taken as objectives for any rehabilitation program:

1. The people displaced should get an appropriate share in the fruits of development.
2. Creating new settlements with their own environment should rehabilitate them.
3. Removal of poverty should also be an objective of the rehabilitation policy and therefore some land to all.
4. Oustees (even the landless) should be given assurance of employment.
5. While dealing with tribal one should also keep in mind the following five principles of tribal-development accepted during Jawaharlal Nehru's era as 'tribal panchsheel.'
6. Tribal should develop along the lines of their own genius and we should avoid imposing anything on them.
7. We should try to encourage their own traditional arts and culture in every way.
8. Resettlement should be in the neighborhood of their own environment. If resettlement is not possible in the command area, top priority should be given to the development of irrigation facilities and supply of basic inputs for agriculture; drinking water, wells, grazing grounds for cattle schools for the children, primary health care units and other amenities should be arranged. 9. In partly affected village, villagers should be given the option of shifting out with others with the same compensation as available to evacuees.
10. Training facilities should be set up to upgrade the skills of affected people and reservation in jobs should be made for the willing adults among the evacuees.
11. Special attention should be given to the rehabilitation of artisans and village crafts people.
12. Villagers should be taken into confidence at every stage or implementation and they should be educated, through open meetings and discussion about the legalities of the Land Acquisition Act and other rehabilitation provisions.
13. The aid of voluntary agencies planning and implementation programme.

8.4. WASTELAND RECLAMATION

Wasteland is the land area which is ecologically degraded and economically unproductive. These are ecologically unstable lands which are incapable of sustain plant growth. The wastelands include salt-affected lands, sandy areas, gullied areas, undulating uplands, barren hill-ridge etc. Snow covered areas, glacial areas and areas rendered barren after Jhum cultivation are also included in wastelands. Though there are natural causes which render land areas unproductive but man's involvement too has contributed a lot in creation and expansion of wastelands. Extensive deforestation, overgrazing, mining, erroneous agricultural practices, shifting cultivation, and unscientific management are some of the human activities which have converted large portions of arable lands into wastelands. Presently wastelands form significant part of land in all the countries of the world. Of about 167.5 million sq km of world's land surface, about 105.5 million sq km consists of deserts, inhospitable ice covered terrains or rocky surface which cannot be put to any productive use for humans.In india more than half of our country's geographical area (about 175 million ha) is estimated to be wasteland, thus indicating the seriousness of the problem for a country like ours which has to support 1/6th of the world.s population.

Maximum wasteland areas in our country lie in Rajasthan (36 million ha) followed by M.P. and Andhra Pradesh. In Haryana the wastelands cover about 8.4% the total land area and most of it comprises saline, sodic or sandy land areas.

8.4.1 Classification of wastelands

From reclamation point of view wastelands has been classified into three categories

Wasteland can be classified into three forms:

(1) Easily reclaimable,

(2) Reclaimable with some difficulty,

(3) Reclaimable with extreme difficulty.

Easily reclaimable wastelands can be used for agricultural purposes. Those which can be reclaimed with some difficulty can be utilized for agro forestry. Wastelands that are reclaimed with extreme difficulty can be used for forestry or to recreate natural ecosystems.

8.4.2 Wasteland Reclamation Practices

Wastelands require attention and suitable practices for their restoration. Identification of the land area to be reclaimed followed by the study of factors involved in its degradation is the first step to be undertaken for reclamation operation. Different types of wastelands demand different categories of practices to be applied for their effective restoration. Wasteland reclamation and development in our country falls under the purview of Wasteland Development Board, which works to fulfil the following objectives:

- o To improve the physical structure and quality of the marginal soils.
- o To improve the availability of good quality water for irrigating these lands.
- o To prevent soil erosion, flooding and landslides.
- o To conserve the biological resources of the land for sustainable use.

Some important reclamation practices are discussed here.

(i) Land development and leaching: in the vast land areas which are degraded due to presence of excess salts, it is necessary to remove the salts from the root-zone which is usually achieved by leaching i.e. by applying excess amount of water to push down the salts. After a survey of the extent of salinity problem, soil texture, depth of impermeable layer and water table, land levelling is done to facilitate efficient and uniform application of water. After levelling and ploughing, the field is bunded in small plots and leaching is done. In continuous leaching, 0.5 to 1.0 cm water is required to remove 90% of soluble salts from each cm of the soil depending upon texture. If we use intermittent sprinkling with 25 cm water, it reduces about 90% salinity in the upper 60 cm layer

(ii) Drainage: in water-logged soils, reclamation is achieved by removal of excess water through artificial drainage.

(a) Surface drainage: This is used in areas where water stands on the fields after heavy rains by providing ditches to runoff the excess water. Usually 30-45 cm deep ditches lying parallel to each other at20-60 m distance are able to remove 5 cm of water within 24 hours.

(b) Sub-surface drainage: Horizontal sub-surface drainage is provided in the form of perforated corrugated PVC pipes or open-jointed pipes with an envelope of gravel 2-3 m below accumulation of salts almost becomes negligible in this method.

(iii) Irrigation Practices: Surface irrigation with precise land levelling, smoothening and efficient hydraulic design help to reduce water logging and salinity. High frequency irrigation with controlled amount of water helps to maintain better water availability in the upper root zone. Thin and frequent irrigations have been found to be more useful for better crop yield when the irrigation water is saline as compared to few heavy irrigations.

(iv) Selection of tolerant crops and crop rotations: Tolerance of crops to salts is found to range from sensitive, semi-tolerant, tolerant to highly tolerant. Barley, sugar beet and date-palm are highly tolerant crops which do not suffer from any reduction in crop yield even at a high salinity with electrical conductivity (EC) of 10 dS/m. Wheat, sorghum, pearl millet, soyabean, mustard and coconut are salt-tolerant crops. Rice, millets, maize, pulses, sunflower, sugarcane and many vegetables like bottle gourd, brinjal etc. are semi-tolerant. These different crop combinations can be grown on saline soils.

(v) Gypsum amendment: Amendment of sodic soils with gypsum is recommended for reducing soil sodicity as calcium of gypsum replaces sodium from the exchangeable sites.

(vi) Green-manures, fertilizers and biofertilizers: Application of farm yard manure or nitrogen fertilizers have been found to improve saline soils. Green manuring with dhaincha (*Sesbania aculeata*) sunhemp or guar have also been reported to improve salt-affected soils.

Blue green algae have been found to be quite promising as biofertilizers for improving salt-affected soils.

(vii) Afforestation Programmes: Afforestation and reforestration of degraded area with suitable fast growing species such as *Rubinia pseudoacacia* can be done. Afforestation means growing the forest over culturable wasteland. Reforestation is Growing the forest again over the lands where they were existing and was destroyed due to fires, overgrazing, and excessive cutting. Reforestation checks water logging, floods, soil erosion and increase productivity of land.

Social Forestry Programmes mostly focus on strip plantation on road, rail and canal-sides, rehabilitation of degraded forest lands, farm-forestry, waste-land forest development etc.

(viii) Providing surface cover: The easiest way to protect the land surface from soil erosion is of leave crop residue on the land after harvesting.

(ix) Mulching: Here also protective cover of organic matter and plants like stalks, cotton stalks, tobacco stalks etc. are used which reduce evaporation, help in retaining soil moisture and reduce soil erosion.

(x) Changing Ground Topography on Downhill: Running water erodes the hill soil and carries the soil along with it. This can be minimized by following alternation in ground topography:

(xi) Strip farming: Different kinds of crops are planted in alternate strip along the contour.

(xii) Terracing: In this arrangement, the earth is shaped in the form of levelled terraces to hold soil and water. The terrace edges are planted with such plant species which anchor the soil.

(xiii) Contour ploughing: In this arrangement, the ploughing of land is done across the hill and not in up and down style.

(xiv) Leaching: In salt affected land, the salinity can be minimized by leaching them with more water.

RECAPS AND PRACTICES

Walk and Talk

(Facts in brief)

- Some of the world's worst natural disasters are:
  - o 1931 Flood in China, occurred in July-august, 1931 and death toll was estimated between 10,00,000-40,00,000.
  - o 1976 Tangshan earthquake occurred on July 28,1976 in China. Death toll was 450,000.
  - o Earthquake in Gujarat on January 26, 2001caused death of 12300 and tremendous property loss in Bhuj area of the state.
  - o Earthquake and Tsunami in Indian ocean on December 26, 2004 resulted in 2,80,000 deaths in India and Indonesia.
  - o Cyclone Nargis in Myanmar on May 2, 2008 resulted 1,38,366 deaths.
  - o Haiti earthquake on January 12, 2010 resulted deaths of more than 1,60,000 people.
  - o Earthquake on October 8, 2005 caused death of about 100000 people in Jammu and Kashmir and Pakistan Administered Kashmir.
- Disasters are mostly naturally events but the damages caused by them can be minimized by proper preparations and management
- Man's excessive interference to the natural environment often increases the intensity and frequency of natural disasters and their damage.
- Risk Assessment and Vulnerability Analysis greatly help in disaster management
- Modern technologies like Remote Sensing, Sattellite communication, Global Positiong System(GPS), Geographical Information System(GIS), global meterological networks, etc play vital role in management of disasters and lessening the predictable losses due to them
- Resettlement and rehabilitation of people displaced either due to disasters or due to developmental projects is a serious human problem world over.
- Rehabilitation requires a full-fledged system to be adopted and not an adhoc approach.
- Wastelands and their reclamation is a global environmental issue.
- Land resources are limited and due to faulty approaches of man this limited resource is further shrinking.
- Of 167.5 million sq.km of world's land surface, about 105.5 million sq.km is unproductive which cannot be used for any purpose.
- Deforestation and desertification (expansion of deserts or desert like situation) are causes which ultimately render fertile lands waste and unusable.

Practice and Prepare

(Self Tests)

(Multiple choice objective type questions)

1. A devastating earthquake occurred in 2001 in
   a. Punjab b. Maharashtra
   c. Gujarat d. Bihar **Ans. c**

2. 'Hurricanes', 'Typhoons' and 'Willy witlies' are the types of
   a. Cyclones b. Droughts
   c. Tsunamis c. None of the above **Ans. a**

3. Tsunamis are result of
   a. Earthquake b. Cyclone
   c. Drought d. Landslide
   Ans. a. Earthquakes (under seas/oceans)

4. Maximum area of wastelands occurs (in India) in
   a. Madhya Pradesh b. Andhra Pradesh
   c. Rajasthan d. Kashmir
   Ans. c. Rajasthan (36 million hectares)

5. Which among the following is not a wasteland reclamation practice
   a. Leaching b. Drainage
   c. Afforestation d. Deforestation **Ans. d**

6. Waves generated by earthquake are known as
   a. E M waves b. Seismic waves
   c. Primary waves d. Sea waves **Ans. b**

7. Which among the following cannot be a cause of earthquake
   a. Volcanic eruption b. Damming of water
   c. Landslides d. Underground nuclear tests **Ans. c**

8. Cyclones occur frequently in
   e. Tropical regions f. Polar regions
   g. Temperate regions h. None of the above **Ans. a**

9. Which among the following cannot be a cause of landslides
   a. Deforestation b. Drought
   c. Heavy rainfall d. Earthquake **Ans. b**

10. State of Jammu and Kashmir comes under
    a. Earthquake prone region b. Cyclone prone region
    c. Tsunami prone region d. Drought prone region **Ans. a**
11. Which among the following is a landslide prone area
    a. Jammu and Kashmir b. Rajasthan
    c. Kerala c. Maharashtra **Ans. a**
12. In September 2014 Jammu and Kashmir state witnessed
    a. Earthquake b. Drought
    c. Flood d. None of the above
    Ans. c. Flood (and landslides)
13. On April 25, 2015, an earthquake of 7.5 magnitude on Richter scale occurred in
    a. Egypt b. Nepal
    c. Pakistan d. Myanmar
    Ans. b. Nepal (and also in parts of India)
14. Which among the following is not a natural disaster
    a. Tsunami b. Drought
    c. Deforestation d. Cyclone **Ans. c**
15. Which among the following is a natural disaster
    a. Pollution b. Nuclear explosion
    c. Flood d. AIDS **Ans. c**
16. Natural disasters are
    a. Predictable b. Predictable to some extent
    c. Unpredictable d. Mostly unpredictable **Ans. d**
17. Drought is a
    a. Pollution related problem b. Natural disaster
    c. Water logging problem d. Manmade disaster **Ans. b**
18. Nuclear accidents and holocaust is a
    a. Natural disaster b. Manmade disaster
    c. Energy consuming process d. Energy providing technique **Ans. b**
19. Earthquake of 4.0 to 4.9 magnitude on Richter scale are considered to be
    a. Great b. Destructive
    c. Minor d. Insignificant **Ans. c**
20. The point at which first movement occurs during an earthquake iscalled
    a. Epicenter b. Focus
    c. Fault zone d. Focal point **Ans. a**

APPENDICES

APPENDIX 1

Forest (Conservation) Act, 1980 with Amendments Made in 1988

An Act to provide for the conservation of forests and for matters connected therewith or ancillary or incidental thereto.

BE it enacted by Parliament in the Thirty-first Year of the Republic of India as follows:

1. Short title, extent and commencement

(1) This Act may be called the Forest (Conservation) Act, 1980.

(2) It extends to the whole of India except the State of Jammu and Kashmir.

(3) It shall be deemed to have come into force on the 25th day of October, 1980.

2. Restriction on the dereservation of forests or use of forest land for non-forest purpose

Notwithstanding anything contained in any other law for the time being in force in a State, no State Government or other authority shall make, except with the prior approval of the Central Government, any order directing—

(i) that any reserved forest (within the meaning of the expression "reserved forest" in any law for the time being in force in that State) or any portion thereof, shall cease to be reserved;

(ii) that any forest land or any portion thereof may be used for any non-forest purpose;

(iii) that any forest land or any portion thereof may be assigned by way of lease or otherwise to any private person or to any authority, corporation, agency or any other organization not owned, managed or controlled by Government;

(iv) that any forest land or any portion thereof may be cleared of trees which have grown naturally in that land or portion, for the purpose of using it for reforestation.

Explanation: For the purpose of this Section, "non-forest purpose" means the breaking up or clearing of any forest land or portion thereof for—

(a) the cultivation of tea, coffee, spices, rubber, palms, oil-bearing plants, horticultural crops or medicinal plants;

(b) any purpose other than reforestation;

but does not include any work relating or ancillary to conservation, development and management of forests and wildlife, namely, the establishment of check-posts, fire lines, wireless communications and construction of fencing, bridges and culverts, dams, waterholes, trench marks, boundary marks, pipelines or other like purposes.

3. Constitution of Advisory Committee

The Central Government may constitute a Committee consisting of such number of persons as h may deem fit to advise that Government with regard to-

(i) the grant of approval. under Section 2; and

(ii) any other matter connected with the conservation of forests which may be referred to h by the Central Government.

3A. Penalty for contravention of the provisions of the Act

Whoever contravenes or abets the contravention of any of the provisions of Section 2, shall be punishable with simple imprisonment for a period which may extend to fifteen days.

3B. Offences by the Authorities and Government Departments

(1) Where any offence under this Act has been committed -

(a) by any department of Government, the head of the department; or

(b) by any authority, every person who, at the time the offence was committed, was directly in charge of, and was responsible to, the authority for the conduct of the business of the authority as well as the authority;

shall be deemed to be guilty of the offence and shall be liable to be proceeded against and punished accordingly:

Provided that nothing contained in this sub-section shall render the head of the department or any person referred to in clause (b), liable to any punishment if he proves that the offence was committed without his knowledge or that he exercised all due diligence to prevent the commission of such offence.

(2) Notwithstanding anything contained in sub-section (1), where an offence punishable under the Act has been committed by a department of Government or any authority referred to in clause (b) of sub-section (1) and it is proved that the offence has been committed with the consent or connivance of; or is attributable to any neglect on the part of any officer, other than the head of the department, or in the case of an authority, any person other than the persons referred to in clause (b) of sub-section (1), such officer or persons shall also be deemed to be guilty of that offence and shall be liable to be proceeded against and punished accordingly.

4. Power to make rules

(1) The Central Government may, by notification in the Official Gazette, makes rules for carrying out the provisions of this Act.

(2) Every rule made under this Act shall be laid, as soon as may be after it is made, before each House of Parliament, while it is in session, for a total period of thirty days which may be comprised in one session or in two or more successive sessions, and if, before the expiry of the session immediately following the session or the successive sessions aforesaid, both Houses agree in making any modification in the rule or both Houses agree that the rule should not be made, the rule shall thereafter have effect only in such modified form or be of no effect, as the case may be; so, however, that any such modification or annulment shall be without prejudice to the validity of anything previously done under that rule.

5. Repeal and saving

(1) The Forest (Conservation) Ordinance, 1980 is hereby replaced.

(2) Notwithstanding such repeal, anything done or any action taken under the provisions of the said Ordinance shall be deemed to have been done or taken under the corresponding provisions of this Act.

Source: http://www.envfor.nic.in

APPENDIX 2

The Environment (Protection) Act, 1986

Act No. 29 of 1986

[23rd May, 1986]

An Act to provide for the protection and improvement of environment and for matters connected therewith:

WHEREAS the decisions were taken at the United Nations Conference on the Human Environment held at Stockholm in June, 1972, in which India participated, to take appropriate steps for the protection and improvement of human environment;

AND WHEREAS it is considered necessary further to implement the decisions aforesaid in so far as they relate to the protection and improvement of environment and the prevention of hazards to human beings, other living creatures, plants and property;

BE it enacted by Parliament in the Thirty-seventh Year of the Republic of India as follows:

CHAPTER I

PRELIMINARY

1. Short Title, Extend and Commencement

(1) This Act may be called the Environment (Protection) Act, 1986.

(2) It extends to the whole of India.

(3) It shall come into force on such date as the Central Government may, by notification in the Official Gazette, appoint and different dates may be appointed for different provisions of this Act and for different areas.1

2. Definitions

In this Act, unless the context otherwise requires:

(a) "environment" includes water, air and land and the inter-relationship which exists among and between water, air and land, and human beings, other living creatures, plants, micro-organisms and property;

(b) "environmental pollutant" means any solid, liquid or gaseous substance present in such concentration as may be, or tend to be, injurious to environment;

(c) "environmental pollution" means the presence in the environment of any environmental pollutant;

(d) "handling", in relation to any substance, means the manufacture, processing, treatment, package, storage, transportation, use, collection, destruction, conversion, offering for sale, transfer or the like of such substance;

(e) "hazardous substance" means any substance or preparation which, by reason of its chemical or physico-chemical properties or handling, is liable to cause harm to human beings, other living creatures, plants, micro-organisms, property or the environment;

(f) "occupier", in relation to any factory or premises, means a person who has, control over the affairs of the factory or the premises and includes in relation to any substance, the person in possession of the substance;

(g) "prescribed" means prescribed by rules made under this Act.

CHAPTER II

GENERAL POWERS OF THE CENTRAL GOVERNMENT

3. Power of Central Government to Take Measures to Protect and Improve Environment

(1) Subject to the provisions of this Act, the Central Government shall have the power to take all such measures as it deems necessary or expedient for the purpose of protecting and improving the quality of the environment and preventing, controlling and abating environmental pollution.

(2) In particular, and without prejudice to the generality of the provisions of Sub-section (1), such measures may include measures with respect to all or any of the following matters, namely,—

(i) co-ordination of actions by the State Governments, officers and other authorities—

(a) under this Act, or the rules made thereunder, or

(b) under any other law, for the time being in force, which is relatable to the objects of this Act;

(ii) planning and execution of a nationwide programme for the prevention, control and abatement of environmental pollution;

(iii) laying down standards for the quality of environment in its various aspects;

(iv) laying down standards for emission or discharge of environmental pollutants from various sources whatsoever:

PROVIDED that different standards for emission or discharge may be laid down under this Clause from different sources having regard to the quality or composition of the emission or discharge of environmental pollutants from such sources;

(v) restriction of areas in which any industries, operations or processes or class of industries, operations or processes shall not be carried out or shall be carried out subject to certain safeguards;

(vi) laying down procedures and safeguards for the prevention of accidents which may cause environmental pollution and remedial measures for such accidents;

(vii) laying down procedures and safeguards for the handling of hazardous substances;

(viii) examination of such manufacturing processes, materials and substances as are likely to cause environmental pollution;

(ix) carrying out and sponsoring investigations and research relating to problems of environmental pollution;

(x) inspection of any premises, plant, equipment, machinery, manufacturing or other processes, materials or substances and giving, by order, of such directions to such authorities, officers or persons as it may consider necessary to take steps for the prevention, control and abatement of environmental pollution;

(xi) establishment or recognition of environmental laboratories and institutes to carry out the functions entrusted to such environmental laboratories and institutes under this Act;

(xii) collection and dissemination of information in respect of matters relating to environmental pollution;

(xiii) preparation of manuals, codes or guides relating to the prevention, control and abatement of environmental pollution;

(xiv) such other matters as the Central Government deems necessary or expedient for the purpose of securing the effective implementation of the provisions of this Act.

(3) The Central Government may, if it considers it necessary or expedient so to do for the purpose of this Act, by order, published in the Official Gazette, constitute an authority or authorities by such name or names as may be specified in the order for the purpose of exercising and performing such of the powers and functions (including the power to issue directions under Section 5) of the Central Government under this Act and for taking measures with respect to such of the matters referred to in Sub-section (2) as may be mentioned in the order and subject to the supervision and control of the Central Government and the provisions of such order, such authority or authorities may exercise and powers or perform the functions or take the measures so mentioned in the order as if such authority or authorities had been empowered by this Act to exercise those powers or perform those functions or take such measures.

4. Appointment of Officers and Their Powers and Functions

(1) Without prejudice to the provisions of Sub-section (3) of Section 3, the Central Government may appoint officers with such designation as it thinks fit for the purposes of this Act and may entrust to them such of the powers and functions under this Act as it may deem fit.

(2) The officers appointed under Sub-section (1) shall be subject to the general control and direction of the Central Government or, if so directed by that Government, also of the authority or authorities, if any, constituted under Sub-section (3) of Section 3 or of any other authority or officer.

5. Power to Give Directions

Notwithstanding anything contained in any other law but subject to the provisions of this Act, the Central Government may, in the exercise of its powers and performance of its functions under this Act, issue directions in writing to any person, officer or any authority and such person, officer or authority shall be bound to comply with such directions.[3]

Explanation: For the avoidance of doubts, it is hereby declared that the power to issue directions under this Section includes the power to direct:

(a) the closure, prohibition or regulation of any industry, operation or process; or

(b) stoppage or regulation of the supply of electricity or water or any other service.

6. Rules to Regulate Environmental Pollution

(1) The Central Government may, by notification in the Official Gazette, make rules in respect of all or any of the matters referred to in Section 3.

(2) In particular, and without prejudice to the generality of the foregoing power, such rules may provide for all or any of the following matters, namely:

(a) the standards of quality of air, water or soil for various areas and purposes;4

(b) the maximum allowable limits of concentration of various environmental pollutants (including noise) for different areas;

(c) the procedures and safeguards for the handling of hazardous substances;5

(d) the prohibition and restrictions on the handling of hazardous substances in different areas;[6]

(e) the prohibition and restriction on the location of industries and the carrying of process and operations in different areas;[7]

(f) the procedures and safeguards for the prevention of accidents which may cause environmental pollution and for providing for remedial measures for such accidents.[8]

CHAPTER III

PREVENTION, CONTROL AND ABATEMENT OF ENVIRONMENTAL POLLUTION

7. Persons Carrying on Industry Operation, etc., not to Allow Emission or Discharge of Environmental Pollutants in Excess of the Standards

No person carrying on any industry, operation or process shall discharge or emit or permit to be discharged or emitted any environmental pollutants in excess of such standards as may be prescribed.[9]

8. Persons Handling Hazardous Substances to Comply with Procedural Safeguards

No person shall handle or cause to be handled any hazardous substance except in accordance with such procedure and after complying with such safeguards as may be prescribed.[10]

9. Furnishing of Information to Authorities and Agencies in Certain Cases

(1) Where the discharge of any environmental pollutant in excess of the prescribed standards occurs or is apprehended to occur due to any accident or other unforeseen act or event, the person responsible for such discharge and the person in charge of the place at which such discharge occurs or is apprehended to occur shall be bound to prevent or mitigate the environmental pollution caused as a result of such discharge and shall also forthwith—

(a) intimate the fact of such occurrence or apprehension of such occurrence; and

(b) be bound, if called upon, to render all assistance, to such authorities or agencies as may be prescribed.11

(2) On receipt of information with respect to the fact or apprehension on any occurrence of the nature referred to in Sub-section (1), whether through intimation under that Sub-section or otherwise, the authorities or agencies referred to in Sub-section (1) shall, as early as practicable, cause such remedial measures to be taken as necessary to prevent or mitigate the environmental pollution.

(3) The expenses, if any, incurred by any authority or agency with respect to the remedial measures referred to in Sub-section (2), together with interest (at such reasonable rate as the government may, by order, fix) from the date when a demand for the expenses is made until it is paid, may be recovered by such authority or agency from the person concerned as arrears of land revenue or of public demand.

10. Powers of Entry and Inspection

(1) Subject to the provisions of this Section, any person empowered by the Central Government in this behalf12 shall have a right to enter, at all reasonable times with such assistance as he considers necessary, any place—

(a) for the purpose of performing any of the functions of the Central Government entrusted to him;

(b) for the purpose of determining whether and if so in what manner, any such functions are to be performed or whether any provisions of this Act or the rules made thereunder or any notice, order, direction or authorisation served, made, given or granted under this Act is being or has been complied with;

(c) for the purpose of examining and testing any equipment, industrial plant, record, register, document or any other material object or for conducting a search of any building in which he has reason to believe that an offence under this Act or the rules made thereunder has been or is being or is about to be committed and for seizing any such equipment, industrial plant, record, register, document or other material object if he has reason to believe that it may furnish evidence of the commission of an offence punishable under this Act or the rules made thereunder or that such seizure is necessary to prevent or mitigate environmental pollution.

(2) Every person carrying on any industry, operation or process of handling any hazardous substance shall be bound to render all assistance to the person empowered by the Central Government under Sub-section (1) for carrying out the functions under that Sub-section and if he fails to do so without any reasonable cause or excuse, he shall be guilty of an offence under this Act.

(3) If any person wilfully delays or obstructs any persons empowered by the Central Government under Sub-section (1) in the performance of his functions, he shall be guilty of an offence under this Act.

(4) The provisions of the Code of Criminal Procedure, 1973, or, in relation to the State of Jammu & Kashmir, or an area in which that Code is not in force, the provisions of any corresponding law in force in that State or area shall, so far as may be, apply to any search or seizures under this Section as they apply to any search or seizure made under the authority of a warrant issued under Section 94 of the said Code or as the case may be, under the corresponding provision of the said law.

11. Power to Take Sample and Procedure to be Followed in Connection Therewith

(1) The Central Government or any officer empowered by it in this behalf,13 shall have power to take, for the purpose of analysis, samples of air, water, soil or other substance from any factory, premises or other place in such manner as may be prescribed.14

(2) The result of any analysis of a sample taken under Sub-section (1) shall not be admissible in evidence in any legal proceeding unless the provisions of Sub-sections (3) and (4) are complied with.

(3) Subject to the provisions of Sub-section (4), the person taking the sample under Sub-section (1) shall—

(a) serve on the occupier or his agent or person in charge of the place, a notice, then and there, in such form as may be prescribed, of his intention to have it so analysed;

(b) in the presence of the occupier or his agent or person, collect a sample for analysis;

(c) cause the sample to be placed in a container or containers which shall be marked and sealed and shall also be signed both by the person taking the sample and the occupier or his agent or person;

(d) send without delay, the container or the containers to the laboratory established or recognised by the Central Government under Section 12.

(4) When a sample is taken for analysis under Sub-section (1) and the person taking the sample serves on the occupier or his agent or person, a notice under Clause (a) of Sub-section (3), then,—

(a) in a case where the occupier, his agent or person wilfully absents himself, the person taking the sample shall collect the sample for analysis to be placed in a container or containers which shall be marked and sealed and shall also be signed by the person taking the sample, and

(b) in a case where the occupier or his agent or person present at the time of taking the sample refuses to sign the marked and sealed container or containers of the sample as required under Clause (c) of Sub-section (3), the marked and sealed container or containers shall be signed by the person taking the samples, and the container or containers shall be sent without delay by the person taking the sample for analysis to the laboratory established or recognised under Section 12 and such person shall inform the Government Analyst appointed or recognised under Section 12 in writing, about the wilfull absence of the occupier or his agent or person, or, as the case may be, his refusal to sign the container or containers.

12. Environmental Laboratories

(1) The Central Government15 may, by notification in the Official Gazette,—

(a) establish one or more environmental laboratories;

(b) recognise one or more laboratories or institutes as environmental laboratories to carry out the functions entrusted to an environmental laboratory under this Act.16

(2) The Central Government may, by notification in the Official Gazette, make rules specifying,—

(a) the functions of the environmental laboratory;[17]

(b) the procedure for the submission to the said laboratory of samples of air, water, soil or other substance for analysis or tests, the form of the laboratory report thereon and the fees payable for such report;[18]

(c) such other matters as may be necessary or expedient to enable that laboratory to carry out its functions.

13. Government Analysts

The Central Government may, by notification in the Official Gazette, appoint or recognise such persons as it thinks fit and having the prescribed qualifications19 to be Government Analysts for the purpose of analysis of samples of air, water, soil or other substance sent for analysis to any environmental laboratory established or recognised under Sub-section (1) of Section 12.

14. Reports of Government Analysts

Any document purporting to be a report signed by a Government Analyst may be used as evidence of the facts stated therein in any proceeding under this Act.

15. Penalty for Contravention of the Provisions of the Act and the Rules, Orders and Directions

(1) Whoever fails to comply with or contravenes any of the provisions of this Act, or the rules made or orders or directions issued thereunder, shall, in respect of each such failure or contravention, be punishable with imprisonment for a term which may extend to five years with fine which may extend to one lakh rupees, or with both, and in case the failure or contravention continues, with additional fine which may extend to five thousand rupees for every day during which such failure or contravention continues after the conviction for the first such failure or contravention.

(2) If the failure or contravention referred to in Sub-section (1) continues beyond a period of one year after the date of conviction, the offender shall be punishable with imprisonment for a term which may extend to seven years.

16. Offences by Companies

(1) Where any offence under this Act has been committed by a company, every person who, at the time the offence was committed, was directly in charge of, and was responsible to, the company for the conduct of the business of the company, as well as the company, shall be deemed to be guilty of the offence and shall be liable to be proceeded against and punished accordingly:

PROVIDED that nothing contained in this Sub-section shall render any such person liable to any punishment provided in this Act, if he proves that the offence was committed without his knowledge or that he exercised all due diligence to prevent the commission of such offence.

(2) Notwithstanding anything contained in Sub-section (1), where an offence under this Act has been committed by a company and it is proved that the offence has been committed with the consent or connivance of, or is attributable to any neglect on the part of, any director, manager, secretary or other officer of the company, such director, manager, secretary or other officer shall also deemed to be guilty of that offence and shall be liable to be proceeded against and punished accordingly.

Explanation: For the purpose of this Section,—

(a) "company" means any body corporate and includes a firm or other association of individuals;

(b) "director", in relation to a firm, means a partner in the firm.

17. Offences by Government Departments

(1) Where an offence under this Act has been committed by any Department of Government, the Head of the Department shall be deemed to be guilty of the offence and shall be liable to be proceeded against and punished accordingly:

PROVIDED that nothing contained in this Section shall render such Head of the Department liable to any punishment if he proves that the offence was committed without his knowledge or that he exercised all due diligence to prevent the commission of such offence.

(2) Notwithstanding anything contained in Sub-section (1), where an offence under this Act has been committed by a Department of Government and it is proved that the offence has been committed with the consent or connivance of, or is attributable to any neglect on the part of, any officer, other than the Head of the Department, such officer shall also be deemed to be guilty of that offence and shall be liable to be proceeded against and punished accordingly.

CHAPTER IV
MISCELLANEOUS

18. Protection of Action Taken in Good Faith

No suit, prosecution or other legal proceeding shall lie against the government or any officer or other employee of the government or any authority constituted under this Act or any member, officer or other employee of such authority in respect of anything which is done or intended to be done in good faith in pursuance of this Act or the rules made or orders or directions issued thereunder.

19. Cognizance of Offences

No court shall take cognizance of any offence under this Act except on a complaint made by—

(a) the Central Government or any authority or officer authorised in this behalf by that Government,20 or

(b) any person who has given notice of not less than sixty days, in the manner prescribed, of the alleged offence and of his intention to make a complaint, to the Central Government or the authority or officer authorised as aforesaid.

20. Information, Reports or Returns

The Central Government may, in relation to its function under this Act, from time to time, require any person, officer, State Government or other authority to furnish to it or any prescribed authority or officer any reports, returns, statistics, accounts and other information and such person, officer, State Government or other authority shall be bound to do so.

21. Members, Officers and Employees of the Authority Constituted Under Section 3 to be Public Servants

All the members of the authority, constituted, if any, under Section 3 and all officers and other employees of such authority when acting or purporting to act in pursuance of any provisions of this Act or the rules made or orders or directions issued thereunder shall be deemed to be public servants within the meaning of Section 21 of the Indian Penal Code (45 of 1860).

22. Bar of Jurisdiction

No civil court shall have jurisdiction to entertain any suit or proceeding in respect of anything done, action taken or order or direction issued by the Central Government or any other authority or officer in pursuance of any power conferred by or in relation to its or his functions under this Act.

23. Powers to Delegate

Without prejudice to the provisions of Sub-section (3) of Section 3, the Central Government may, by notification in the Official Gazette, delegate, subject to such conditions and limitations as may be specified in the notifications, such of its powers and functions under this Act [except the powers to constitute an authority under Sub-section (3) of Section 3 and to make rules under Section 25] as it may deem necessary or expedient, to any officer, State Government or other authority.

24. Effect of Other Laws

(1) Subject to the provisions of Sub-section (2), the provisions of this Act and the rules or orders made therein shall have effect notwithstanding anything inconsistent therewith contained in any enactment other than this Act.

(2) Where any act or omission constitutes an offence punishable under this Act and also under any other Act, then the offender found guilty of such offence shall be liable to be punished under the other Act and not under this Act.

25. Power to Make Rules

(1) The Central Government may, by notification in the Official Gazette, make rules for carrying out the purposes of this Act.

(2) In particular, and without prejudice to the generality of the foregoing power, such rules may provide for all or any of the following matters, namely,—

(a) the standards in excess of which environmental pollutants shall not be discharged or emitted under Section 7;21

(b) the procedure in accordance with and the safeguards in compliance with which hazardous substances shall be handled or caused to be handled under Section 8;22

(c) the authorities or agencies to which intimation of the fact of occurrence or apprehension of occurrence of the discharge of any environmental pollutant in excess of the prescribed standards shall be given and to whom all assistance shall be bound to be rendered under Sub-section (1) of Section 9;23

(d) the manner in which samples of air, water, soil or other substance for the purpose of analysis shall be taken under Sub-section (1) of Section 11;24

(e) the form in which notice of intention to have a sample analysed shall be served under Clause (a) of Sub-section (3) of Section 11;25

(f) the functions of the environmental laboratories,26 the procedure for the submission to such laboratories of samples of air, water, soil and other substances for analysis or test;27 the form of laboratory report; the fees payable for such report and other matters to enable such laboratories to carry out their functions under Sub-section (2) of Section 12;

(g) the qualifications of Government Analyst appointed or recognised for the purpose of analysis of samples of air, water, soil or other substances under Section 13;28

(h) the manner in which notice of the offence and of the intention to make a complaint to the Central Government shall be given under Clause (b) of Section 19;29

(i) the authority of officer to whom any reports, returns, statistics, accounts and other information shall be furnished under Section 20;

(j) any other matter which is required to be, or may be, prescribed.

26. Rules Made Under this act to be Laid Before Parliament

Every rule made under this Act shall be laid, as soon as may be after it is made, before each House of Parliament, while it is in session for a total period of thirty days, which may be comprised in one session or in two or more successive sessions, and if, before the expiry of the session immediately following the session or the successive sessions aforesaid, both Houses agree in making any modification in the rule or both Houses agree that the rule should not be made, the rule shall thereafter have effect only in such modified form or be of no effect, as the case may be; so, however, that any such modification or annulment shall be without prejudice to the validity of anything previously done under that rule.

ADDENDUM

SAMPLE QUESTION PAPER

(for Ba/Bsc/BCom Sem III of Jammu University)

Maximum Marks: 35

Time: 45 minutes

- *Each question is followed by four optional answers. Select the correct or the most appropriate answer and darken the relevant circle against that question on OMR sheet*
- *Each question carries one marks*
- *All questions are compulsory*

1. According to IPCC, earth's mean temperature has risen during the last century by

   a. Approximately 0.4°C b. Approximately 0.6°Cpproxi

   c. Approximately 0.8°C d. Approximately 1.0°C

2. Convention on Biological Diversity adopted at UNCED in 1992 aimed at conservation of

   a. Biological species b. Habitats

   c. Ecosystems d. All of the above

3. Which of the following purification technology removes mineral pullutants from water

   a. Filtration b. Osmosis

   c. Reverse osmosis d. UV treatment

4. Primary and secondary sewage treatments removes BOD by

   a. 30-40% b. 50-60%

   c. 60- 70% d. 70-80%

5. DDT is an environmental pollutant and is harmful mainly because it undergoes
   a. Biotransformation
   b. Biodiversification
   c. Bioaccumulation
   d. Biomagnifications
6. Which among the following gaseous pollutants may cause death among humans by binding with hemoglobin
   a. CO
   b. CO_2
   c. O_2
   d. None of the above
7. Who among the following is not an ecologist
   a. E P Odum
   b. Ernest Haekel
   c. Bill Gates
   d. Clements
8. Syncology studies
   a. Individual species
   b. Individual genes
   c. Group of individuals or species
   d. All of the above
9. Which is not an atmospheric layer
   a. Ozonosphere
   b. Troposphere
   c. Mesosphere
   d. Hydrosphere
10. Tropical rain forests are
    a. Very rich in biodiversity
    b. Very poor in biodiversity
    c. Rich source of medicinal plants
    d. Good source of sandalwood
11. Acid rain is a result of
    a. Atmospheric pollution
    b. God's blessing
    c. Hydrospheric pollution
    d. Acidification of water
12. Pyramid of energy in a forest or desert ecosystem will be
    a. Always inverted
    b. Always upright
    c. Inverted or upright
    d. Spindle shaped
13. Rio declaration is also called as
    a. Earth charter
    b. Earth hour
    c. Earth convention
    d. None of the above
14. Water (Prevention and Control of Pollution Act) was enacted in India in
    a. 1972
    b. 1971
    c. 1988
    d. 1974

15. The Environment (Protection) Act, 1986 applies to
    a. Whole of India
    b. Whole of India except J&K
    c. Whole of India except Tripura and Assam
    d. Whole of India except Kerala
16. Wildlife (Protection) Act, 1972 extends to
    a. The whole of India
    b. The whole of India, except the State of Jammu and Kashmir
    c. The whole of India, except the State of Maharashtra
    d. The whole of the north India
17. Ecosystem is a
    a. Static system
    b. Dynamic and functional system
    c. Only a structural system
    d. Biological system
18. Using microorganisms to remove pollutants is known as
    a. Biomeditation
    b. Biomagnification
    c. Bioremediation
    d. Bioremediation
19. Mangrove forests in India are found in the state of
    a. Jammu and Kashmir
    b. West Bengal
    c. Gujarat
    d. Punjab
20. Estuary is an example of
    a. Aquatic ecosystem
    b. Transitional ecosystem
    c. Marine ecosystem
    d. Both a and b
21. Which is not a green house gas
    a. Methane
    b. Carbon monoxide
    c. Nitrous oxide
    d. None of the above
22. In nitrogen cycle, soil nitrates are transformed into free nitrogen by
    a. Nitrifying bacteria
    b. Ammonifying bacteria
    c. Denitrifying bacteria
    d. None of the above
23. Fjord is an example of
    a. Terrestrial ecosystem
    b. Aquatic ecosystem
    c. Forest ecosystem
    d. Grassland ecosystem
24. Maximum density of water is at
    a. 4°C
    b. 100°C
    c. 200°C
    d. 0°C

25. Methyl isocyanate(MIC) is associated with
    a. Bhopal gas tragedy
    b. Nuclear holocaust
    c. Minamata disease
    d. Love canal tragedy

26. Eurtophication in lakes is
    a. Enrichment of nutrients
    b. Decline of nutrients
    c. Rise of temperature
    d. Increase of mineral salts

27. Which among the following causes acid rain\
    a. Sulphur dioxide
    b. Nitrogen dioxide
    c. Carbon dioxide
    d. Both a and b

28. Xerophytes are found in a
    a. Desert
    b. Forest
    c. Grassland
    d. Lake

29. In India, tropical rain forests are found in
    a. Goa
    b. Assam
    c. Jammu and Kashmir
    d. Kerala

30. Basic principal underlying environmental ethics is
    a. Live and let every creature live
    b. Kill the beasts
    c. Protect plants and animals
    d. Save humans

31. Which type of forests are not found in J&
    a. Temperate forest
    b. Coniferous forest
    c. Sal forest
    d. Deodar forest

32. Identify the natural disaster
    a. Green house effect
    b. Acid rain
    c. Global warming
    d. Flood

33. Which among the following is not an effect of environmental pollution
    a. Acid rain
    b. Global warming
    c. Necrosis in plants
    d. Landslide

34. What is thermal pollution
    a. Normal heating of a water body
    b. Entry of hot water into a water body causing harmful effect in it
    c. Entry of harmful substances into a water body
    d. Abnormal cooling of a water body

35. Typhoid, cholera, hepatitis, etc are the diseases caused due to

a. Air pollution	b. Water pollution
c. Noise pollution	d. Radioactive pollution

ANSWER KEY

1 c.	2 d.	3 c.	4 c.	5 c.
6 a.	7 c.	8 c.	9 d.	10 a.
11 a.	12 b.	13 a.	14 d.	15 a.
16 b.	17 b.	18 d	19 b	20 d
21 d	22 c	23 b	24 a	25 a
26 a	27 d	28 a	29 d	30 a
31 c	32 d	33 d	34 b	35 b

GLOSSARY

Terms used in environmental and ecological studies

- **5Rs** - (sustainability) reduce, remanufacture, reuse, recycle, and recover.
- **Abiotic** - non-living chemical and physical factors of the environment (see also biotic).
- **Absorption** - one substance taking in another, either physically or chemically.
- **Acid rain** - rain or other forms of precipitation that is unusually acidic.
- **Adaptation** - a characteristic of an organism that has been favoured by natural selection.
- **Adsorption** - one substance taking up another at its surface.
- **Aerobic** - requiring air or oxygen; used in reference to decomposition processes that occur in the presence of oxygen.
- **Aerosols** - solid or liquid particles suspended within the atmosphere.
- **Afforestation** - planting new forests on lands that have not been recently forested.
- **Agroforestry** - (sustainability) an ecologically based farming system, that, through the integration of trees in farms, increases social, environmental and economic benefits to land users.
- **Air pollution** - the modification of the natural characteristics of the atmosphere by a chemical, particulate matter, or biological agent.
- **Albedo** - reflectance; the ratio of light from the Sun that is reflected by the Earth's surface, to the light received by it. Unreflected light is converted to infrared radiation (heat), which causes atmospheric warming (see "radiative forcing"). Thus, surfaces with a high albedo, like snow and ice, generally contribute to cooling, whereas surfaces with a low albedo, like forests, generally contribute to warming. Changes in land use that significantly alter the characteristics of land surfaces can alter the albedo.

- **Algal bloom** - the rapid and excessive growth of algae; generally caused by high nutrient levels combined with other favourable conditions. Blooms can deoxygenate the water leading to the loss of wildlife.
- **Anaerobic** - not requiring air or oxygen; used in reference to decomposition processes that occur in the absence of oxygen.
- **Anoxic** - with abnormally low levels of oxygen.
- **Anthropogenic** - man-made, not natural.
- **Aquaculture** - the cultivation of aquatic organisms under controlled conditions.
- **Aquifer** – a bed or layer yielding water for wells and springs etc.; an underground geological formation capable of receiving, storing and transmitting large quantities of water.
- **Arable land** - land that can be used for growing crops.
- **Atmosphere** – general name for the layer of gases around a material body
- **Autotroph** - an organism that produces complex organic compounds from simple inorganic molecules using energy from light or inorganic chemical reactions.
- **Bioaccumulation** - the accumulation of a substance, such as a toxic chemical, in the tissues of a living organism.
- **Biodegradable** - capable of being decomposed through the action of organisms, especially bacteria.
- **Biodiversity** - the variety of life in all its forms, levels and combinations; includes ecosystem diversity, species diversity, and genetic diversity.
- **Biogas** - landfill gas and sewage gas, also called biomass gas.
- **Biogeochemical cycles** - the movement of chemical elements between organisms and non-living components of the atmosphere, aquatic systems and soils.
- **Biological oxygen demand (BOD)** - a chemical procedure for determining how fast biological organisms use up oxygen in a body of water.
- **Biological pest control** - a method of controlling pests (including insects, mites, weeds and plant diseases) that relies on predation, parasitism, herbivory, or other natural mechanisms.
- **Biomass** - the quantity of organic material present in unit area at a particular time; organic matter that can be used as fuel.
- **Biome** - a climatic and geographically defined area of ecologically similar communities of plants, animals, and soil organisms, often referred to as ecosystems.
- **Biosphere** - the part of the Earth, including air, land, surface rocks, and water, within which life occurs, and which biotic processes in turn alter or transform.
- **Boreal** - northern; cold temperate Northern Hemisphere forests that grow where there is a mean annual temperature < 0°C.

- **Calorific value –** the energy content of a fuel measured as the heat released on complete combustion.
- **Carbon budget –** a measure of carbon inputs and outputs for a particular activity.
- **Carcinogen –** a substance, radionuclide or radiation that is an agent directly involved in the promotion of cancer or in the facilitation of its propagation.
- **Carrying capacity –** the maximum population that an ecosystem can
- **Catchment area –** the area that is the source of water for a water supply whether a dam or rainwater tank.
- **Cell –** (biology) the structural and functional unit of all known living organisms and is the smallest unit of an organism that is classified as living
- **CFC-chlorofluorocarbons** – one of the more widely known family of haloalkanes.
- **Compost –** the aerobically decomposed remnants of organic matter.
- **Composting –** the biological decomposition of organic materials in the presence of oxygen that yields carbon dioxide, heat, and stabilised organic residues that may be used as a soil additive.
- **Convention on the International Trade in Endangered Species (CITES)** – International agreement among 167 governments aiming to ensure that cross-border trade in wild animals and plants does not threaten their survival. The species covered by CITES are listed in three
- **Crop rotation (crop sequencing) –** the practice of growing a series of dissimilar types of crops in the same space in sequential seasons for various benefits such as to avoid the buildup of pathogens and pests that often occurs when one species is continuously cropped.
- **DDT -** a chlorinated hydrocarbon used as a pesticide that is a persistent organic pollutant.
- **Decomposers –** consumers, mostly microbial, that change dead organic matter into minerals and heat.
- **Deforestation -** the conversion of forested areas to non-forest land for agriculture, urban use, development, or wasteland.
- **Desertification -** the degradation of land in arid, semi arid and dry sub-humid areas resulting from various climatic variations, but primarily from human activities.
- **Detritivore (detritus feeder) -** animals and plants that consume detritus (decomposing organic material), and in doing so contribute to decomposition and the recycling of nutrients.
- **Dioxin -** any one of a number of chemical compounds that are persistent organic pollutants and are carcinogenic.
- **Drainage -** (water management) that part of irrigation or rainfall that runs off an area or is lost to deep percolation.

- o **Ecolabel -** seal or logo indicating a product has met a certain environmental or social standards.
- o **Ecological succession -** the more-or-less predictable and orderly changes in the composition or structure of an ecological community with time.
- o **El Niño -** a warm water current which periodically flows southwards along the coast of Ecuador and Peru in South America, replacing the usually cold northwards flowing current; occurs once every five to seven years, usually during the Christmas season (the name refers to the Christ child); the opposite phase of an El Niño is called a La Niña.
- o **Emission standard -** a level of emissions that, under law, may not be exceeded.
- o **Emissions -** substances such as gases or particles discharged into the atmosphere as a result of natural processes of human activities, including those from chimneys, elevated point sources, and tailpipes of motor vehicles.
- o **Endangered species -** a species which is at risk of becoming extinct because it is either few in number, or threatened by changing environmental or predation parameters.
- o **Energetics -** the study of how energy flows within an ecosystem: the routes it takes, rates of flow, where it is stored and how it is used.
- o **Geothermal energy -** heat emitted from within the Earth's crust as hot water or steam and used to generate electricity after transformation;
- o **Enhanced greenhouse effect -** the increase in the natural greenhouse effect resulting from increases in atmospheric concentrations of greenhouse gases due to emissions from human activities.
- o **ENSO (El Niño–Southern Oscillation) -** a suite of events that occur at the time of an El Niño; at one extreme of the cycle, when the central Pacific Ocean is warm and the atmospheric pressure over Australia is relatively high, the ENSO causes drought conditions over eastern Australia cf. El Niño, Southern Oscillation.
- o **Erosion -** displacement of solids (sediment, soil, rock and other particles) usually by the agents of currents such as, wind, water, or ice by downward or down-slope movement in response to gravity or by living organisms.
- o **Escherichia coli (E. coli) -** a bacterium used as an indicator of faecal contamination and potential disease organisms in water.
- o **Estuary -** a semi-enclosed coastal body of water with one or more rivers or streams flowing into it, and with a free connection to the open sea.
- o **Eutrophication -** the enrichment of waterbodies with nutrients, primarily nitrogen and phosphorus, which stimulates the growth of aquatic organisms.
- o **Evaporation -** water converted to water vapour.
- o **Evapotranspiration (ET) -** the water evaporating from the soil and transpired by plants.

- **e-waste -** electronic waste, especially mobile phones, televisions and personal computers.
- **Extinction -** the cessation of existence of a species or group of taxa, reducing biodiversity.
- **Forest –** land with a canopy cover greater than 30%.
- **Fossil fuel -** any hydrocarbon deposit that can be burned for heat or power, such as coal, oil and natural gas (produces carbon dioxide when burnt);
- **Gaia hypothesis -** an ecological hypothesis that proposes that living and nonliving parts of the earth are a complex interacting system that can be thought of as a single organism.
- **Gene pool -** the complete set of unique alleles in a species or population.
- **Genetic diversity -** one of the three levels of biodiversity that refers to the total number of genetic characteristics.
- **Greenhouse effect -** the process in which the emission of infrared radiation by the atmosphere warms a planet's surface.
- **Greenhouse gas -** components of the atmosphere that contribute to the greenhouse effect.
- **Green manure -** a type of cover crop grown primarily to add nutrients and organic matter to the soil.
- **Green Revolution -** the ongoing transformation of agriculture that led in some places to significant increases in agricultural production between the 1940s and 1960s.
- **Genetic engineering -** the use of various experimental techniques to produce molecules of DNA containing new genes or novel combinations of genes, usually for insertion into a host cell for cloning; the technology of preparing recombinant DNA in vitro by cutting up DNA molecules and splicing together fragments from more than one organism; the modification of genetic material by man that would otherwise be subject to the forces of nature only.
- **Genome -** the total genetic composition of an organism
- **Geothermal energy -** energy derived from the natural heat of the earth contained in hot rocks, hot water, hot brine or steam.
- **Global warming -** the observable increase in global temperatures considered mainly caused by the human induced enhanced greenhouse effect trapping the Sun's heat in the Earth's atmosphere.
- **Greenhouse gases -** any gas that contributes to the greenhouse effect
- **Greywater -** household waste water that has not come into contact with toilet waste; includes water from baths, showers, bathrooms, washing machines, laundry and kitchen sinks.

- **Habitat -** an ecological or environmental area that is inhabited by a particular species.
- **Herbicide -** a chemical the kills or inhibits growth of a plant.
- Heterotroph - an organism that requires organic substrates to obtain its carbon for growth and development.
- **Humus -** organic material in soil lending it a bark brown or black colouration.
- **Hydrocarbons -** chemicals made up of carbon and hydrogen that are found in raw materials such as petroleum, coal and natural gas.
- **Hydroelectric power -** the electrical power generated using the power of falling water.
- **Hydrosphere** - all the Earth's water; this would include water found in the sea, streams, lakes and other waterbodies, the soil, groundwater, and in the air.
- **Incineration -** combustion (by chemical oxidation) of waste material to treat or dispose of that waste material.
- **Indicator species -** any biological species that defines a trait or characteristic of the environment.
- **Infiltration -** the process by which water on the ground surface enters the soil.
- **Insecticide -** a pesticide used to control insects in all developmental forms.
- **Integrated Pest Management (IPM) -** a pest control strategy that uses an array of complementary methods: natural predators and parasites, pest-resistant varieties, cultural practices, biological controls, various physical techniques, and the strategic use of pesticides.
- **Intercropping -** the agricultural practice of cultivating two or more crops in the same space at the same time.
- **Keystone species -** a species that has a disproportionate effect on its environment relative to its abundance, affecting many other organisms in an ecosystem and help in determine the types and numbers of various others species in a community.
- **Landfill -** solid waste disposal in which refuse is buried between layers of soil, a method often used to reclaim low-lying ground; the word is sometimes used as a noun to refer to the waste itself.
- **Landfill gas –** the gas emissions from biodegrading waste in landfill, including CO2, CH_4, and small amounts of nitrogen, oxygen with traces of toluene, benzene and vinyl chloride.
- **Land use planning -** a branch of public policy which encompasses various disciplines which seek to order and regulate the use of land in an efficient and ethical way.
- **Leaching -** the movement of chemical in the upper layers of soil into lower layers or into groundwater by being dissolved in water.
- **Lithosphere -** the solid outermost shell of a rocky planet considered ideal for gardening and agricultural uses.

- **Leaf area index (LAI) -** the ratio of photosynthetic leaf area to ground area covered.
- **Loam -** a soil composed of sand, silt, and clay in relatively even concentration (about 40-40-20% concentration respectively), *locally existing capacity - the total ecological production that is found within a country's territories. It is usually expressed in hectares based on world average productivity.
- **Magma -** molten rock that sometimes forms beneath the surface of the Earth (or any other terrestrial planet) that often collects in a magma chamber and is ejected by volcanoes.
- **Material flow -** the cycling of materials, which is driven by the flow of energy.
- **Megadiverse countries** - The 17 countries that are home to the largest fraction of wild species (Australia is one such)
- **Microorganism -** an organism visible only through a microscope.
- **Monoculture -** the practice of producing or growing one single crop over a wide area.
- **Mortality rate -** generally understood as the total number of deaths per 1000 people of a given age group
- **Mulch -** any composted or non-composted organic material, excluding plastic, which is suitable for placing on soil surfaces to restrict moisture loss from the soil and to provide a source of nutrients to the soil.
- **Municipal waste -** solid waste generated from domestic premises (garbage and hard waste) and council activities such as street sweeping, litter and street tree lopping.
- **Natural resources -** naturally occurring substances that are considered valuable in their relatively unmodified form.
- **Natural selection -** the process by which favorable heritable traits become more common in successive generations of a population and unfavorable heritable traits become less common.
- **Net primary production -** the energy or biomass content of plant material that has accumulated in an ecosystem over a period of time through photosynthesis.
- **Nonpoint source pollution -** water pollution affecting a water body from diffuse sources, rather than a point source which discharges to a water body at a single location.
- **Nutrients -** chemicals required for the growth of organisms
- **Oceania -** the islands of the southern, western, and central Pacific Ocean, including Melanesia, Micronesia, and Polynesia.
- **Omnivore -** a species of animal that eats both plants and animals as its primary food source.

- **Open-pit mining or opencast mining -** a method of extracting rock or minerals from the earth by their removal from an open pit or borrow.
- **Organic agriculture -** a holistic production management system that avoids the use of synthetic fertilisers, pesticides and GM organisms, minimises pollution of air, soil and water, and optimises the health and productivity of interdependent communities of plants, animals and people.
- **Pesticide -** means any substance or mixture of substances intended for preventing, destroying or controlling any pest.
- **Photosynthesis -** the transformation of radiant energy to chemical energy by plants; the manufacture by plants of carbohydrates from carbon dioxide and water. The reaction is driven by energy from sunlight, catalysed by chlorophyll and releases oxygen as a byproduct.
- **Photovoltaic -** the direct conversion of light into electricity
- **Plankton -** mostly microscopic animal and plant life suspended in water and a valuable food source for animals.
- **Polluter Pays Principle (PPP) -** the principle that producers of pollution should in some way compensate others for the effects of their pollution.
- **Polyvinyl chloride (PVC) -** a member of the vinyl family of plastics. PVC can be clear, flexible or rigid and is used to make products such as juice bottles, credit cards,
- **Precipitation -** any liquid or solid water particles that fall from the atmosphere to the Earth's surface; includes drizzle, rain, snow, snow pellets, ice crystals, ice pellets and hail
- **Primary productivity -** the fixation rate at which solar energy is fixed by plants.
- **Productivity (ecology) -** the rate at which radiant energy is used by producers to form organic substances as food for consumers.
- **Pyrolysis -** advanced thermal technology involving the thermal decomposition of organic compounds in the complete absence of oxygen under pressure and at elevated temperature.
- **Rainwater harvesting -** collecting rainwater either in storages or the soil mostly close to where it falls.
- **Rangeland -** a region where grazing or browsing livestock is the main land use.
- **Recycling -** a wide range of activities, including collection, sorting, reprocessing and manufacture of products into new goods.
- **Reforestation -** the direct human conversion of non-forested land to forested land through planting or seeding on land that was once forested but no longer so.
- **Renewable energy -** any source of energy that can be used without depleting its reserves. These sources include sunlight (solar energy) and other sources such as, wind, wave, biomass, geothermal and hydro energy.

- **Respiration -** uptake by a living organism of oxygen from the air (or water) which is then used to oxidise organic matter or food. The outputs of this oxidation are usually CO_2 and H_2O.
- **Salinisation -** the process by which land becomes salt-affected.
- **Salinity -** salt in water and soils; can make soils infertile.
- **Sediment -** soil or other particles that settle to the bottom of water bodies.
- **Sequestration -** the removal of carbon dioxide from the Earth's atmosphere and storage in a sink as when trees absorb CO_2 in photosynthesis and store it in their tissues.
- **Sewage -** water and raw effluent disposed through toilets, kitchens and bathrooms.
- **Sewerage -** a system of pipes and mechanical appliances for the collection and transportation of domestic and industrial sewages.
- **Sinks -** processes or places that store gases, solutes or solids.
- **Sludge -** waste in a state between liquid and solid.
- **Sodification -** the build-up in soils of sodium relative to potassium and magnesium in the composition of the exchangeable cations of the clay fraction.
- **Soil bulk density -** the relative density of a soil measured by dividing the dry weight of a soil by its volume.
- **Solar energy -** the radiant energy of the Sun, which can be converted into other forms of energy, such as heat or electricity.
- **Solar power -** electricity generated from solar radiation.
- **Solid waste -** non-hazardous, non-prescribed solid waste materials ranging from municipal garbage to industrial waste.
- **Surface runoff -** the part of rainfall passing out of an area into the drainage system.
- **Suspended solids (SS) -** solid particles suspended in water; used as an indicator of water quality.
- **Sustainability -** development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
- **System -** a set of parts organised into a whole, usually processing a flow of energy.
- **Technosphere -** synthetic and composite components and materials formed by human activity.
- **Threshold -** a point that, when crossed, can bring rapid and sometimes unpredictable change in a trend. An example would be the sudden altering of ocean currents due to the melting of ice at the poles.
- **United Nations -** an international organisation based in New York and formed to promote international peace, security, and cooperation under a charter signed by 51 founding countries in San Francisco in 1945

- **Volatile organic compound (VOC) -** molecules containing carbon and differing proportions of other elements such as hydrogen, oxygen, fluorine and chlorine. With sunlight and heat they form ground-level ozone.
- **Watershed -** a water catchment area (North America) or drainage divide (non-American usage).
- **Weather -** the hourly/daily change in atmospheric conditions which over a longer period constitute the climate of a region.
- **Wetlands -** areas of permanent or intermittent inundation, whether natural or artificial, with water that is static or flowing, fresh, brackish or salt.
- **Wind energy -** the kinetic energy present in the motion of the wind. Wind energy can be converted to mechanical or electrical energy.
- **Zero waste -** turning waste into resource; the redesign of resource-use so that waste can ultimately be reduced to zero.

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