Environmental Studies

SIMPLIFIED

Third Edition

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Dedicated to

My Beloved Parents and Wife

CONTENTS

PREFACE

Introduction to the Course

A course on Environmental Studies or Environmental Science and Engineering is offered with the intention of imparting an understanding of the impact of technological solutions in societal and environmental contexts, and to enable the students to demonstrate the knowledge of, and need for sustainable development. Basic topics such as natural resources, ecology, biodiversity, and environmental pollution are dealt in detail in this book. In addition to these topics, the concept of sustainable development and population growth related issues are also discussed.

Target Audience

This textbook is designed to cater to the needs of all the discerning learners of this course at undergraduate level in Indian universities. Efforts are made to accommodate the widest possible variations in the background of the students.

Objective of the Revision

Since the first edition of Environmental Studies, the level of environmental awareness among the general public and graduate students of India have gone up extensively, and hence it was felt that a lot of introductory explanations and details in the earlier edition were becoming incongruous. The above perspective is the rationale behind this edition and it is also kept in mind that the course on Environmental Studies should not be felt as a difficult requirement or unnecessary academic hurdle by the students. The main objective of this revision is to ease the learning curve and to reduce the amount of time to complete the course successfully without omitting the core concepts. The strategy adopted for attaining the above objective is the conversion of considerable amount of theory to graphical representations. In addition to the above, facts and figures are updated based on recent developments around the world.

Roadmap to Target Courses

For courses offered in engineering programmes, all the topics dealt in this book may be taken up with careful details. For other degree programmes, some of the topics such as water treatment, wastewater treatment, air pollution control equipment, municipal solid waste management, etc. may be dealt with a lesser rigorousness.

What is New in This Edition

A large number of illustrations and tables are added to this version for easy understanding by converting the existing knowledge base. Every chapter is provided with learning outcomes to make the learning process more focused and conclusion based.

Organization of the Book

Chapter 1 tries to sensitize the students about the importance of Environmental Studies and its multidisciplinary nature. It also draws a broader picture of the role of human beings in biosphere and major environmental issues that our planet is currently facing.

Chapter 2 deals in major natural resources such as water, forest, minerals and energy resources. It also highlights the current issues affecting these natural resources and possible ways for conservation. Topics relating to food security and land resources are also discussed in detail.

Chapter 3 discusses ecosystems and biogeochemical cycles. The material and energy flow in an ecosystem is illustrated and the same is compared with that of an anthroposystem.

Chapter 4 looks at biodiversity, its importance, threats to biodiversity, and conservation efforts. India as a mega biodiverse nation is discussed and some of the endemic species facing extinction are also highlighted.

Chapter 5 on environmental pollution discusses air, water, soil and marine pollution in detail with their causes, effects and solutions. Some associated topics such as noise pollution and thermal pollution are also discussed. The issue of management of municipal solid waste and hazardous waste is illustrated in detail.

Chapter 6 introduces the concept of sustainable development and looks at the underlying social concerns behind the environmental issues. Topics such as climate change and ozone hole are dealt in detail here.

Chapter 7 considers the universal issues relating to human population changes (both growth and reduction) in various parts of the globe. Topics such as human rights, HIV and value education are also dealt here.

Acknowledgements

The author wishes to place on record his heartfelt thanks to the entire editorial team of McGraw Hill Education, India, for their hand-holding during the revision process with a special mention of Ms Piyali Chatterjee and Mr Atul Gupta. I would express my gratitude to Ms Shobhika Puri for painstakingly making all the illustrations within the chapters. I would also like to acknowledge various reviewers who took out time to review this book and gave their valuable feedback and suggestions. Their names are given below.

Himanshu Sharma	*Meerut Institute of Engineering and Technology, Meerut, Uttar Pradesh*
Laiju A.R.	*National Institute of Technology Uttarakhand, Uttarakhand*
Kritanjali Jaiswal	*Girijananda Chowdhury Institute of Management and Technology, Guwahati, Assam*
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Debapriya Dey	*MCKV Institute of Engineering, Howrah, West Bengal*

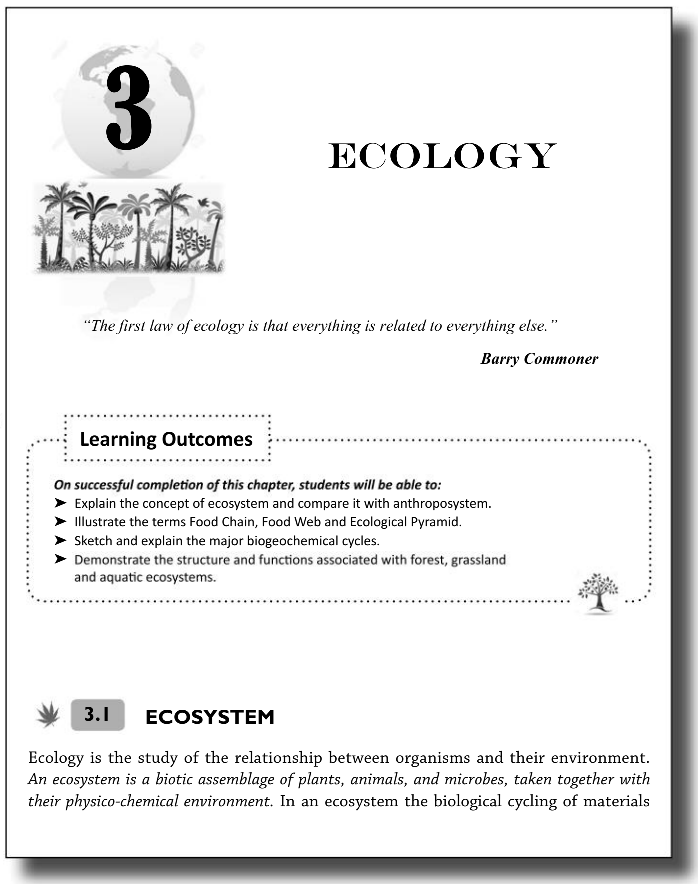
Benny Joseph

VISUAL WALKTHROUGH

The readers can take a tour of this book through the visual walkthrough given below. It highlights different elements present within the chapters and also gives a brief introduction about them.

Learning Objectives

Chapters are organized into multiple learning objectives which help students and instructors to indulge in planned and focussed learning of concepts.



3

ECOLOGY

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

Barry Commoner

Learning Outcomes

On successful completion of this chapter, students will be able to:

- Explain the concept of ecosystem and compare it with anthroposystem.
- Illustrate the terms Food Chain, Food Web and Ecological Pyramid.
- Sketch and explain the major biogeochemical cycles.
- Demonstrate the structure and functions associated with forest, grassland and aquatic ecosystems.

3.1 ECOSYSTEM

Ecology is the study of the relationship between organisms and their environment. *An ecosystem is a biotic assemblage of plants, animals, and microbes, taken together with their physico-chemical environment.* In an ecosystem the biological cycling of materials

Figures and Tables

The figures illustrate the various concepts discussed in the chapter. This makes the learning process stimulating. Details pertaining to different concepts have been presented in tabular form at various places.

A typical rainwater harvesting facilty for a building is shown in Fig. 6.4.

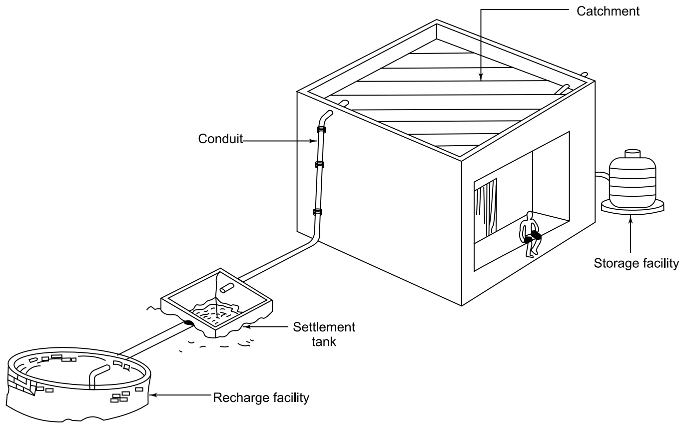


Fig. 6.4 *Typical Rainwater Harvesting Facility for a Building*

Table 2.2 *Advantages and Disadvantages of Various Energy Types*

Energy type	*Advantages*	*Disadvantages*
Renewable	■ Wide availability ■ Lower running cost ■ Decentralized power production ■ Low pollution ■ Available for the foreseeable future	■ Unreliable supply ■ Usually produced in small quantities ■ Often very difficult to store ■ Currently per unit cost of energy is more compared to other types
Non-renewable	■ Available in highly concentrated form ■ Easy to store ■ Reliable supply ■ Lower cost per unit of energy produced as the technology is matured	■ Highly polluting ■ Available only in a few places ■ High running cost ■ Limited supply and will one day get exhausted
Sustainable (Nuclear power)	■ Highly reliable ■ Produces large amounts of energy with very little CO_2 emissions ■ Uses small amount of raw material per unit energy production	■ Risk of radioactivity ■ High waste disposal costs ■ High capital investment and maintenance cost

Case Studies and Burning Topics

Latest case studies and burning topics are also covered in book for better understanding of different topics.

CASE STUDY

Canada: Education, Migration, Divorce Cause, Fall in Birth Rate

Canada's birth rate fell to 10.5 births for every 1,000 people, down by 25% in the last decade of 20th century. Women are having the same 1.5 babies that they've been having for the past 10 years but there are fewer women in the fertile age group 25 to 30. Experts point to an array of factors, including increasing education for women, the urbanization of society and the breakdown in family units. Where a new generation was born every 20 years, it's now closer to 30. When you increase the time between generations, there will be fewer children. All agree that the fertility rate has seen a decline over the last 40 years. One factor is higher education that has given women career opportunities that caused women to delay pregnancies until their careers have been established. Education has also given women better knowledge about birth control products. The move to urban living has an effect as agrarian societies, babies are viewed as a source of future labour supply but in urban settings, children are more likely to be economic drains on their parents. Urban parents rely on pension plans, rather than their children. Many working class women are putting off children because they simply can't afford to support them. Family change, such as divorce, cohabitation and looseness of relationships, comes with fewer children because there's less security.

BURNING TOPIC

Climate Change: An Inconvenient Truth

Weather is the mix of events that happen every day in our atmosphere including temperature, rainfall and humidity. Climate is the average weather pattern in a place over many years.

Climates will change if the factors that influence them fluctuate. To change climate on a global scale, either the amount of heat that is let into the system changes, or the amount of heat that is let out of the system changes. For instance, warming climates are either due to increased heat let into the Earth or a decrease in the amount of heat that is let out of the atmosphere.

In the early 19th century, scientists discovered that trace amounts of atmospheric gases, including carbon dioxide and methane, were responsible for retaining some of the sun's heat in the lower atmosphere. They theorized that without these gases, the earth's temperature would not support the variety of life found on this planet. However, the huge amount of fossil fuels burned since the Industrial Revolution has increased the atmospheric concentration of these gases and dramatically changed the energy balance of the planet, retaining heat that otherwise would be radiated out into space. Like the glass in a greenhouse, this raises the average air temperature in the lower atmosphere.

The gases responsible for this phenomenon are known as **greenhouse gases (GHG)**. CO_2 is the major GHG and the other gases that could contribute this effect are identified as CH_4, N_2O, HFCs (hydrofluorocarbons), PFCs (perfluorocarbons) and SF_6 (sulphur hexafluoride) (Fig. 6.11).

Chapter-end Exercise

More than 400 chapter-end exercises are constructed to assess the student's understanding of concepts discussed in each chapter. These are formed as objective-type questions, short-answer questions and descriptive questions. Answer to MCQs have been provided at the end of each chapter.

REVIEW QUESTIONS

Objective-Type Questions

1. As per the FAO definition the minimum percentage of depletion of tree crown cover, that can be considered as deforestation is
(a) 50% (b) 60%
(c) 70% (d) 90%

2. Which of the following statements about the forest is not correct?
(a) Reduces soil erosion
(b) Provides recrea
(c) Provides a sou
(d) None of the ab

3. Which of the foll environment?
(a) Clear felling
(b) Reduced impac
(c) Mechanized lo
(d) Hand logging

Short-Answer Questions

1. Define the term *deforestation*.
2. Differentiate between deforestation and forest degradation.
3. Cite examples for aesthetic, recreational, economic, historical, cultural and religious values of forests around your place.
4. List the effects of deforestation.
5. List the possible social impacts of mining on local communities.
6. Write a short note on the mineral resources of India.
7. Identify the core causes of curren
8. Define *meteorological drought*.
9. Define *food security*.
10. Enumerate the desired qualities o
11. Define organic farming.
12. List the advantages of organic ag
13. What are the major energy source
14. Differentiate between renewable, with examples.

Descriptive Questions

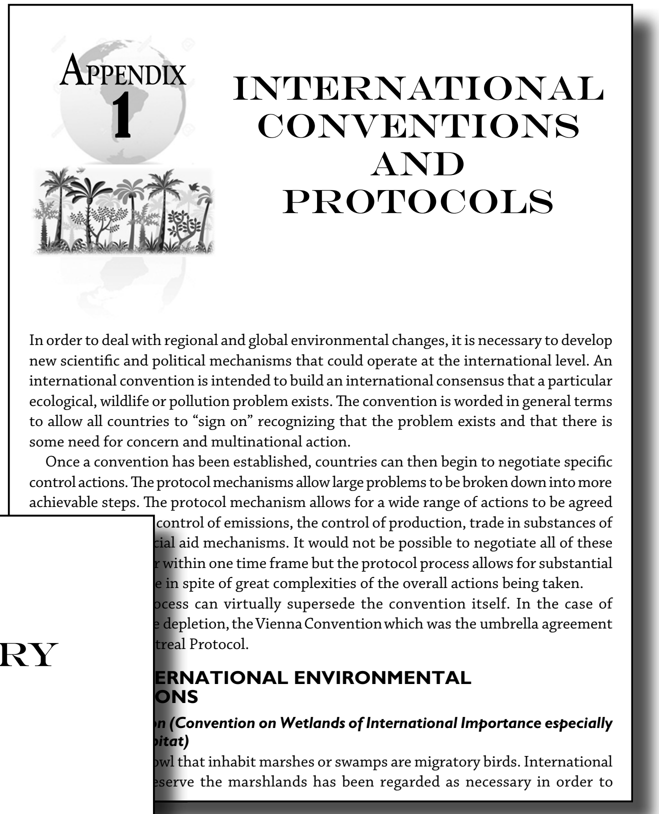
1. Describe the history of population growth on earth mentioning the factors contributing to it.
2. Draw a typical population pyramid of a developing country and discuss how it is likely to differ from that of a developed country.
3. Explain the environmental problems posed by population explosion.
4. Discuss the salient features of the Universal Declaration of Human Rights by UN.
5. Explain the steps that are being taken in India to impart value education from school days.
6. Discuss the process of HIV infection.
7. What are the modes of transmission of HIV and how can it be prevented?
8. What are the steps that have to be taken to control the AIDS epidemic in India?
9. Discuss the role of Information Technology in the protection of environment and human health.

Answers to Objective-Type Questions

1. (c)	2. (b)	3. (b)	4. (b)	5. (b)	6. (d)	7. (a)
8. (b)	9. (d)	10. (c)	11. (d)	12. (b)	13. (b)	14. (a)
15. (d)						

Appendices

- Book-end appendix will give the reader knowledge about major International Environmental Conventions and Environmental Protocols.
- Glossary of technical terms frequently used in environmental science has been included at the end of book. This will help readers improve their vocabulary on the subject.



Appendix 1

INTERNATIONAL CONVENTIONS AND PROTOCOLS

In order to deal with regional and global environmental changes, it is necessary to develop new scientific and political mechanisms that could operate at the international level. An international convention is intended to build an international consensus that a particular ecological, wildlife or pollution problem exists. The convention is worded in general terms to allow all countries to "sign on" recognizing that the problem exists and that there is some need for concern and multinational action.

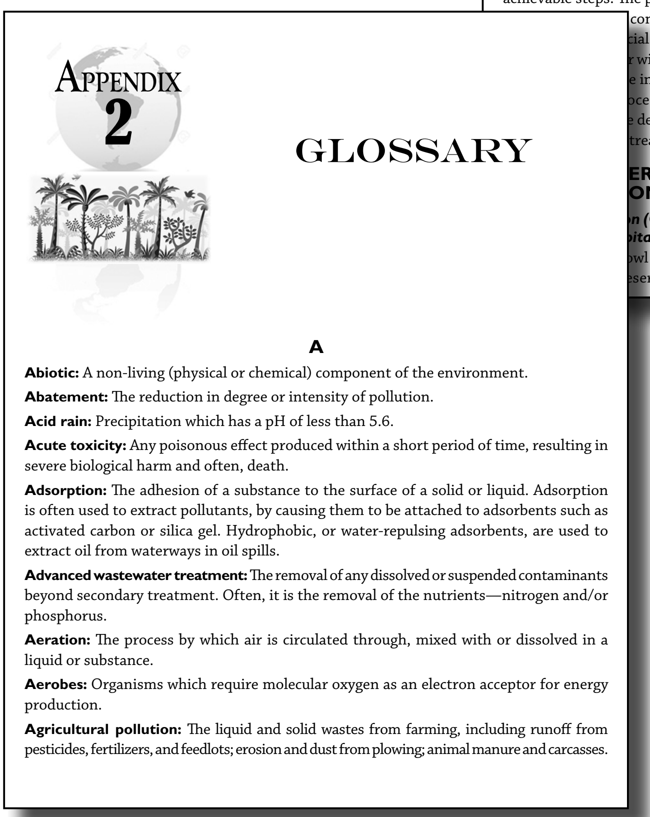
Once a convention has been established, countries can then begin to negotiate specific control actions. The protocol mechanisms allow large problems to be broken down into more achievable steps. The protocol mechanism allows for a wide range of actions to be agreed control of emissions, the control of production, trade in substances of cial aid mechanisms. It would not be possible to negotiate all of these r within one time frame but the protocol process allows for substantial e in spite of great complexities of the overall actions being taken.

ocess can virtually supersede the convention itself. In the case of e depletion, the Vienna Convention which was the umbrella agreement treal Protocol.

ERNATIONAL ENVIRONMENTAL ONS

n (Convention on Wetlands of International Importance especially bitat)

owl that inhabit marshes or swamps are migratory birds. International eserve the marshlands has been regarded as necessary in order to



Appendix 2

GLOSSARY

A

Abiotic: A non-living (physical or chemical) component of the environment.

Abatement: The reduction in degree or intensity of pollution.

Acid rain: Precipitation which has a pH of less than 5.6.

Acute toxicity: Any poisonous effect produced within a short period of time, resulting in severe biological harm and often, death.

Adsorption: The adhesion of a substance to the surface of a solid or liquid. Adsorption is often used to extract pollutants, by causing them to be attached to adsorbents such as activated carbon or silica gel. Hydrophobic, or water-repulsing adsorbents, are used to extract oil from waterways in oil spills.

Advanced wastewater treatment: The removal of any dissolved or suspended contaminants beyond secondary treatment. Often, it is the removal of the nutrients—nitrogen and/or phosphorus.

Aeration: The process by which air is circulated through, mixed with or dissolved in a liquid or substance.

Aerobes: Organisms which require molecular oxygen as an electron acceptor for energy production.

Agricultural pollution: The liquid and solid wastes from farming, including runoff from pesticides, fertilizers, and feedlots; erosion and dust from plowing; animal manure and carcasses.

1 INTRODUCTION

"The earth provides enough to satisfy every person's need but not every person's greed."

Mahatma Gandhi

Learning Outcomes

On successful completion of this chapter, students will be able to:

➤ Demonstrate an understanding of the significance of environmental education.
➤ Outline the Gaia theory in the context of environmentalism.
➤ Comprehend the multidisciplinary nature of the course Environmental Studies.
➤ Illustrate the components of the environment and its interactions.
➤ Outline the causes, effects and management options for various environmental problems related to air, water and land.

1.1 GENERAL

Throughout history, humankind has adapted to the natural variations of the earth's system and its climate. However, in the last century, human population and consumption of various natural resources have increased significantly and this essentially is the root cause of all the environmental issues. Figure 1.1 shows some of the current impacts of human activities on the environment.

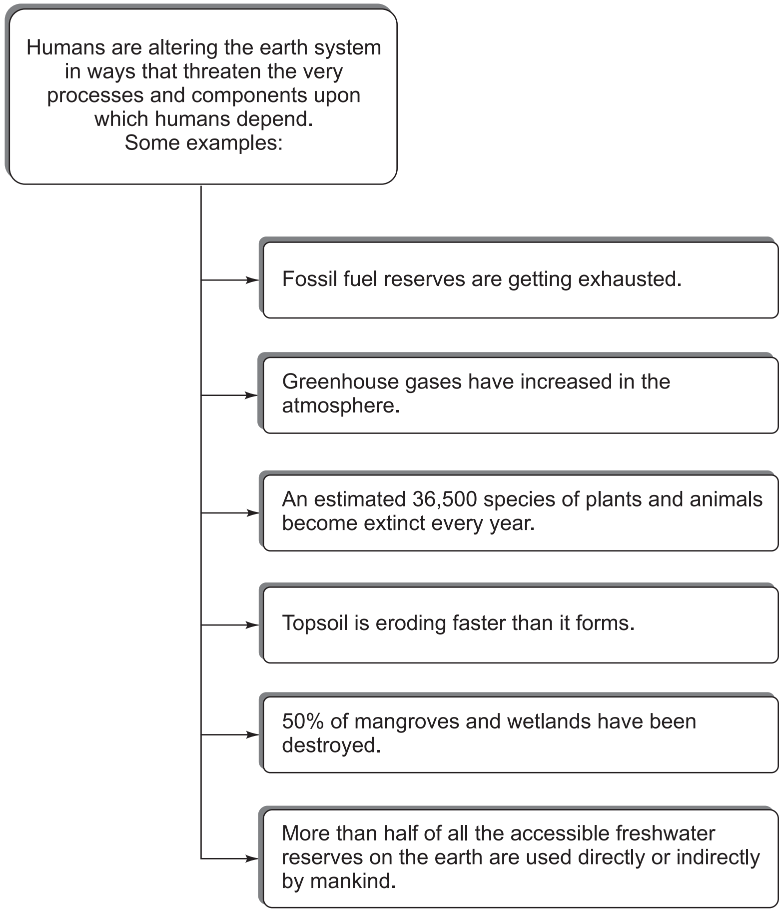


Fig. 1.1 *Impacts of Human Activities on the Environment*

Environmental awareness among the public and policymakers has been growing since the 1960s, when it became widely recognized that human activities were having harmful and largescale effects on the environment.

1.2 IMPORTANCE OF ENVIRONMENTAL EDUCATION

Environment is the physical and biotic habitat that surrounds us. Environmental issues affect, and are affected by, all our activities to varying degrees. The need to have a working knowledge of environmental issues is not confined to environmental scientists, engineers and policymakers. In our society, all the educated citizens need to have a working understanding of the fundamental principles involved in environmentally responsible decision-making to protect planet earth. Figure 1.2 lists some of the functions of environmental education.

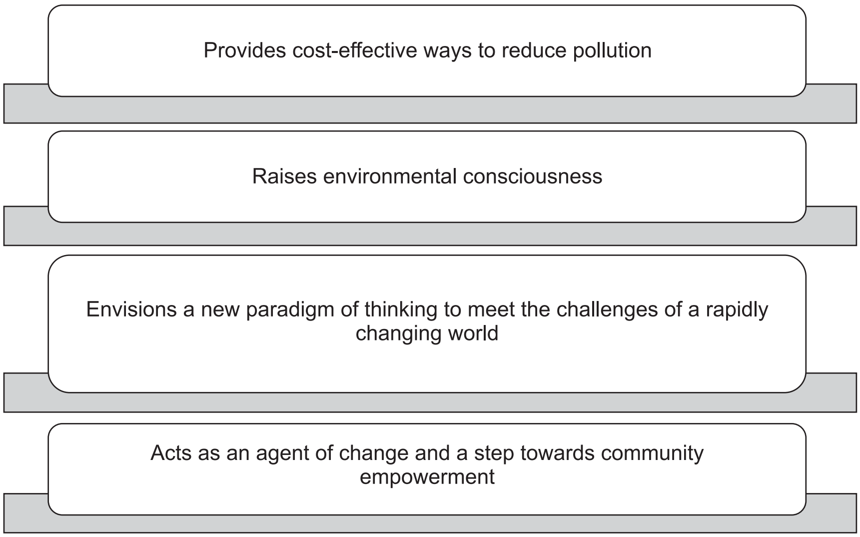


Fig. 1.2 *Functions of Environmental Education*

The following are some of the guiding principles and features suggested for effective environmental education.

Environmental Education

- Considers the environment in its totality, i.e., ecological, political, natural, technological, sociological, aesthetic and built environments.
- Develops awareness of the importance, beauty and wonders that can be found in these aspects of the environment.
- Explores not only the physical qualities of the human relationship with the environment, but also the spiritual aspect of this relationship.
- Is a response to the challenge of moving towards an ecologically and socially sustainable world.
- Is concerned with the interaction between the quality of the biophysical environment and the socio-economic environment.
- Transcends the division of knowledge, skills and attitudes by seeking commitment to action in an informed manner to realistic sustainability.
- Recognizes the value of local knowledge, practices and perceptions in enhancing sustainability.

- Supports relevant education by focusing on learning local environments.
- Considers the global as well as the local environment. Since the world is a set of inter-related systems, there is a need for a world perspective on environmental issues.
- Focuses on current and future perspectives on environmental conditions.
- Is interdisciplinary and can be taught through and used to enhance all subjects in the curriculum.
- Emphasizes participation in preventing and solving environmental problems and revokes the passive accumulation of information about the environment.

Environmental literacy is the capability for a contextual and detailed understanding of an environmental problem in order to enable analysis, synthesis, evaluation, and ultimately sound and informed decision-making at a citizen's level.

1.3 ENVIRONMENTAL ENGINEERING

Environmental Engineering is one of the most complex and fastest growing disciplines of Engineering. The scope of this field includes issues from public health protection to aesthetics, and from impact on business development to the development of legislation, standards, regulations, and guidelines, to their enforcement and environmental protection.

A challenging aspect of Environmental Engineering is the rapid changes in the field due to the rate of knowledge increase in the fields of science, technology and health. Figure 1.3 illustrates some of the core areas of Environmental Engineering.

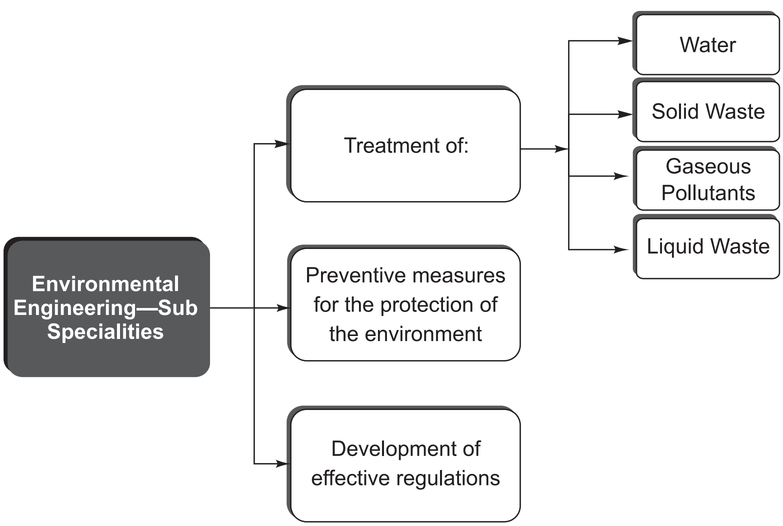


Fig. 1.3 *Some Core Areas of Environmental Engineering*

1.4 ENVIRONMENTALISM

Although it can be argued that environmental consciousness is ancient, and forms part of many religions, it was not until the 1960s that environmentalism became an organized force. The milestone marking the birth of the environmental movement was the publication of the book ***Silent Spring*** by Rachel Carson in 1962 in the USA. *Silent Spring* inspired a new public awareness that human beings were harming the environment. Since the 1960s, the movement has grown dramatically. In *Silent Spring*, Carson exposed the perils of the indiscriminate use of pesticides, particularly DDT (dichlorodiphenyltrichloroethane).

Exposed the perils of excessive use of pesticides like DDT	DDT accumulates in animals and humans in two ways	Government actions
▪ DDT was earlier considered as a miracle. ▪ Carson explained how DDT enters the food chain, causing cancer and genetic damage. ▪ Predicted massive destruction of the planet's ecosystem.	▪ Humans consume DDT directly when they eat food sprayed with the pesticide. DDT does not breakdown easily and accumulates in the body. ▪ Accumulates indirectly by increasing in concentration up the food chain.	▪ Banned in the US in 1972. ▪ 122 nations signed the Stockholm Convention treaty to phase out DDT. This has not been taken up everywhere like some African nations.

Fig. 1.4 ***Silent Spring by Rachel Carson*** *– The book that marked the Birth of Environmental Movement*

1.4.1 The Gaia Theory

Named after the Greek mother Earth goddess, Gaia, the theory was developed in the 1960s by scientist Dr James Lovelock. This theory suggests a holistic view of the world, where all life on earth interacts with the physical environment to form a complex system that can be thought of as a single super organism. Thus, the earth acts as a superorganism with the ability to regulate environmental conditions needed to sustain itself, as much as the human body keeps its water content, temperature, and other conditions at a relatively constant state to keep the body alive. Lovelock believed that the earth is a self-regulating system and is able to keep its climate and chemical composition comfortable for living organisms. In particular, it regulates the chemistry of the oceans, composition of the atmosphere and the surface temperature. The film Avatar (2009) is an illustration of the Gaia theory where a world (Pandora) functions like a single organism.

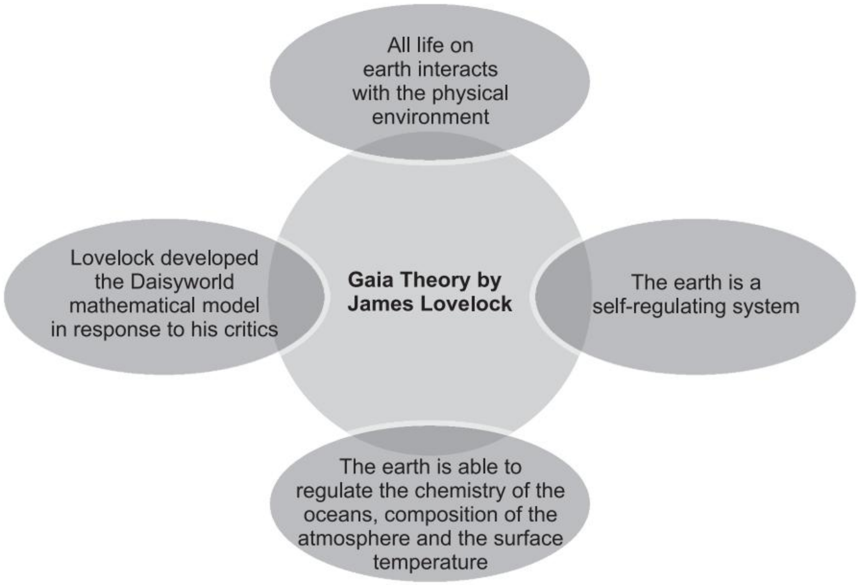


Fig. 1.5 *Lovelock and the Gaia Theory*

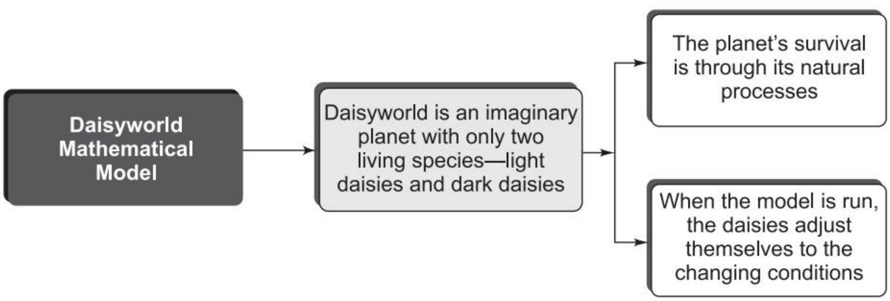


Fig. 1.6 *Daisyworld Mathematical Model*

1.5 ENVIRONMENTAL STUDIES—THE SUBJECT AND ITS MULTIDISCIPLINARY NATURE

Environmental Studies is a distinct programme that gives the students an opportunity to experience the interdisciplinary nature of the subject. Environmental Studies educate students in the fundamentals of environmental and social sciences along with major environmental issues.

An understanding of the working of the environment requires the knowledge from wide-ranging fields. Table 1.1 shows a list of topics dealt commonly in air pollution and the related traditional fields of knowledge, illustrating the interdisciplinary nature of the subject.

Table 1.1 *Interdisciplinay Nature of the Subject—Air Pollution*

Environmental issue/Topic	*Major subject/Topic knowledge required*
Nature and reactions of air pollutants	Chemistry and Chemical Engineering
Effects of air pollutants on human beings, animals, plants and materials	Zoology and Botany and various branches of life science, Physics, and Chemistry
Effect of climate on air pollution	Meteorology, Thermodynamics, Geography, Mathematical modelling, etc.
Air pollution control devices	Physics, Chemistry and various branches of Engineering
History of air pollution and air pollution episodes	History
Economic impacts of air pollution	Economics, Demography
Sociological impacts of air pollution	Sociology
Alternative fuels	Various branches of physical sciences
Conservation of resources and pollution control	Various branches of physical and political sciences
Ozone hole and global warming	Almost every branch of study has got something to contribute to the understanding of this phenomenon.

1.6 COMPONENTS OF THE ENVIRONMENT AND THEIR INTERACTIONS

Chemicals on earth are distributed among four major environmental components or conceptual spheres—atmosphere, hydrosphere, lithosphere and biosphere. While such a classification of nature is arbitrary, it helps in organizing and extending our knowledge of distribution and flow of chemicals. A schematic representation of the four environmental components and their interrelationships is shown in Fig. 1.7. The circles represent the spheres and the curved arrows the flow pathways of the matter. In the diagram, circles and curved arrows are used instead of boxes and straight line connections to emphasize the close, dynamic, inseparable, organic coupling among the environmental components. If one component or linkage changes, all other components respond. In this conceptual frame, every sphere has a two-way linkage to every other sphere, including itself. The two-way linkage signifies that the matter may flow from one component to another in both directions. Some arrows show the transfer within a given component from one location to another indicating movement of the substance from one physical location to another without leaving the sphere. Since matter cannot be created or destroyed, the major objective is to find the location and chemical form of the substance at any given time.

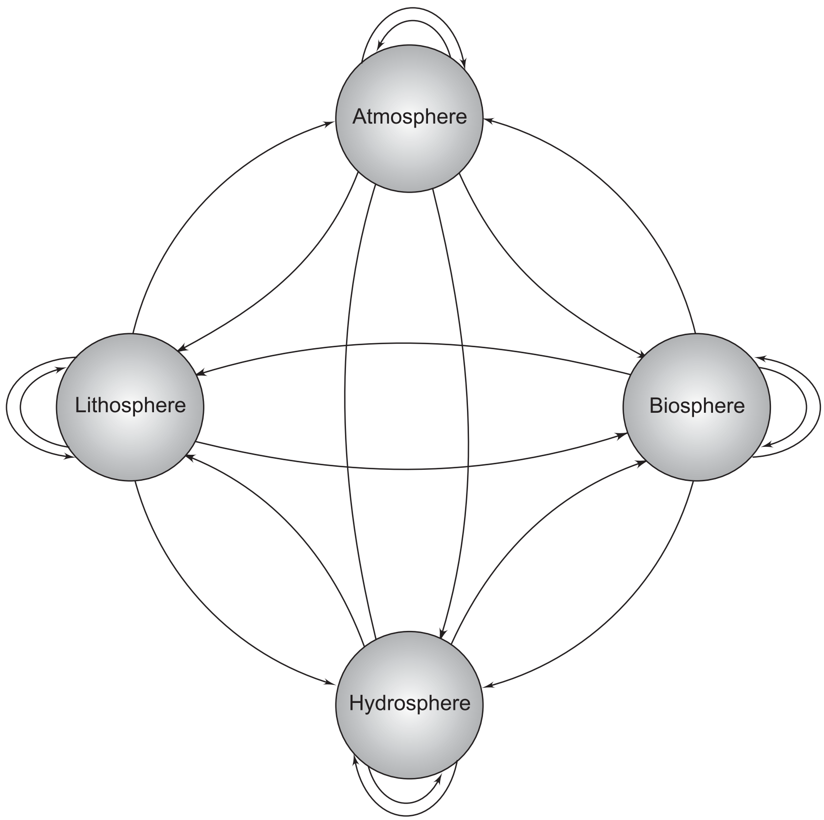


Fig. 1.7 *Components of the Environment*

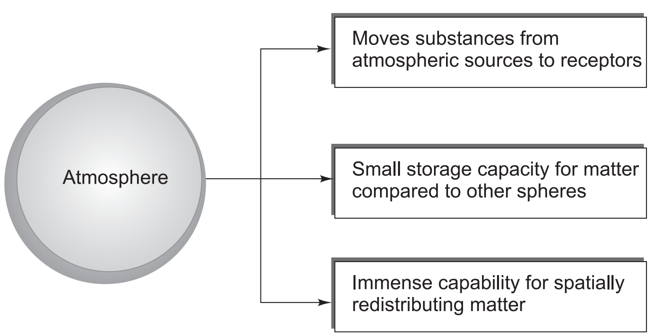


Fig. 1.7(a) *Atmosphere*

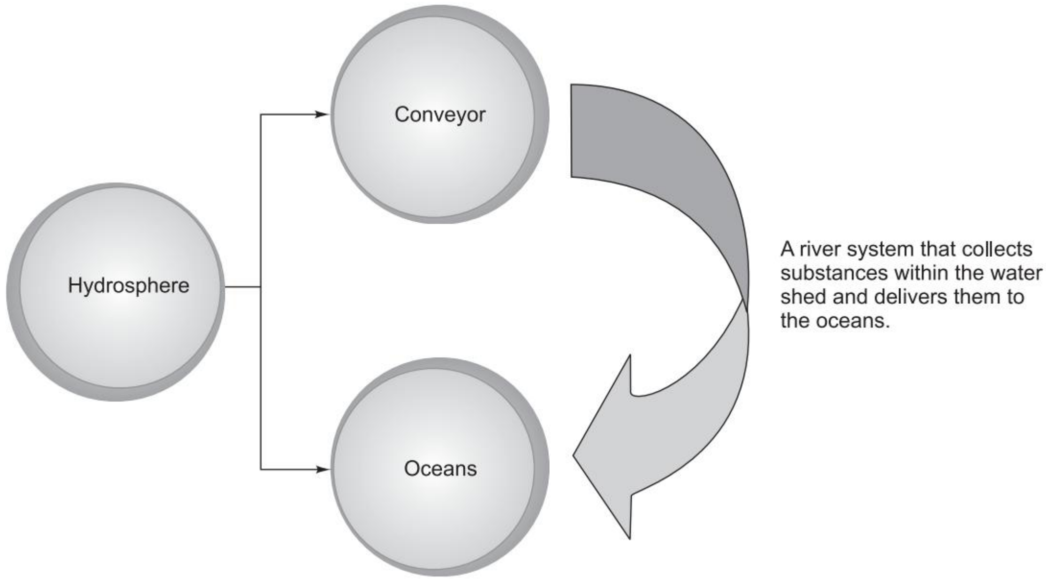


Fig. 1.7(b) *Hydrosphere*

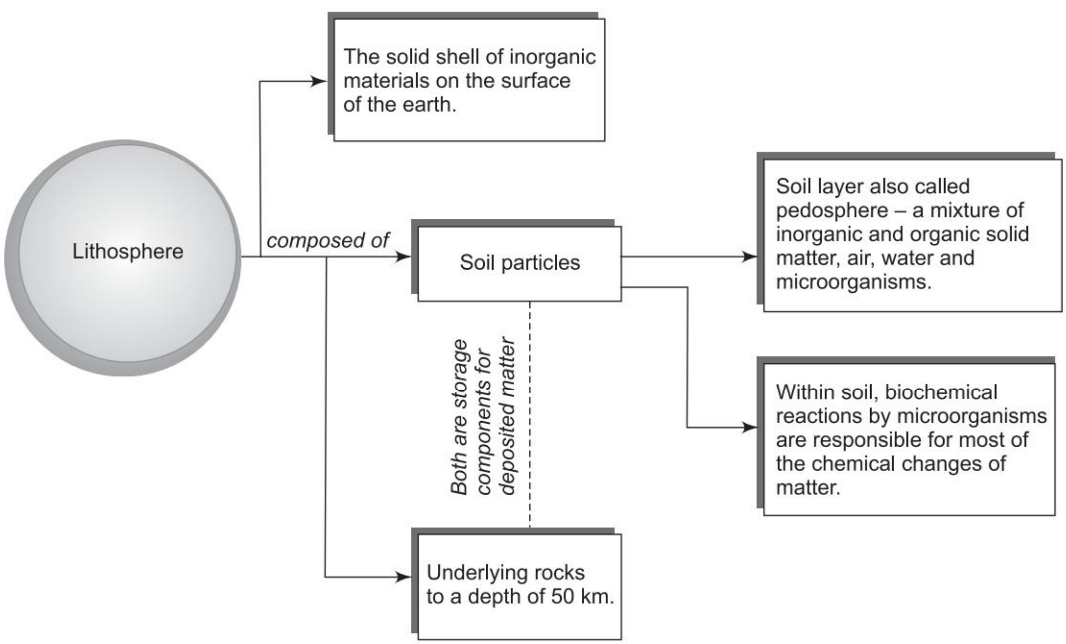


Fig. 1.7(c) *Lithosphere*

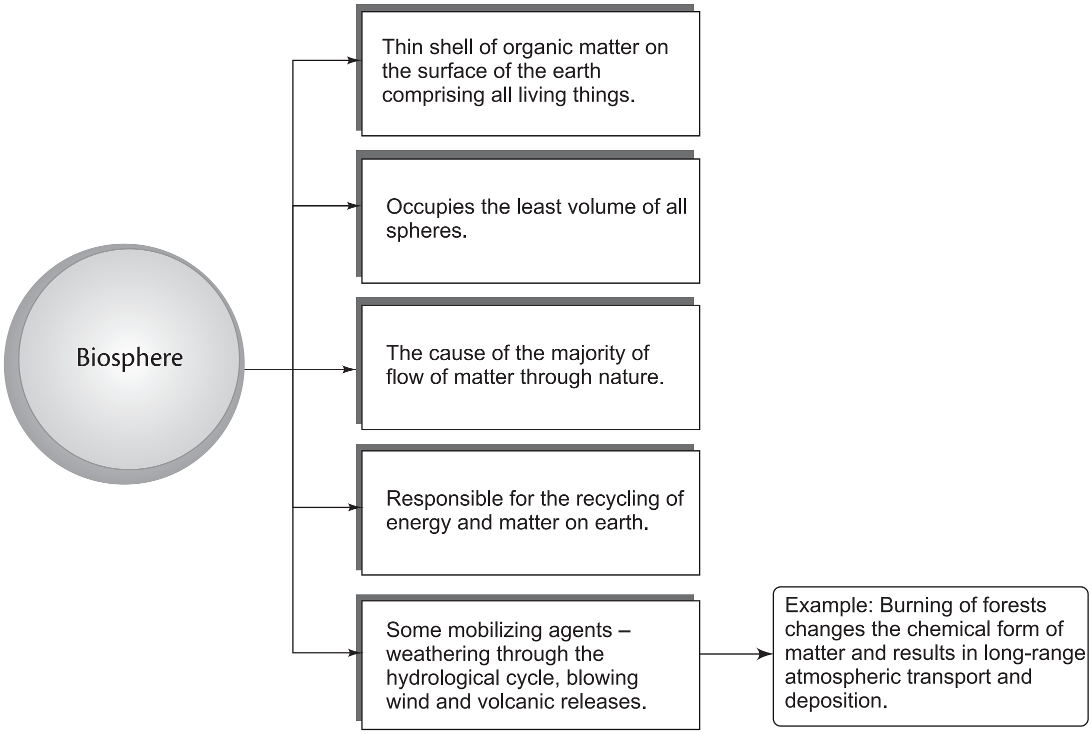


Fig. 1.7(d) *Biosphere*

1.7 HUMANS AND THE BIOSPHERE

Humans are part of the biosphere, and human activities most closely resemble the functions of the biosphere. Humans are responsible for the largescale redistribution of chemicals on earth. Population explosion, coupled with increased per capita consumption of natural resources, is the root cause of all the adverse human impacts on the biosphere.

The atmosphere and the hydrosphere are effective transporters of matter; and, as a result, many of the anthropogenic chemicals are transferred to the land or the oceans where they are subsequently incorporated in these long-term geochemical reservoirs. Much of the environmental damage is done in the atmosphere, hydrosphere, lithosphere and biosphere during the transit from one long-term geochemical reservoir to another.

1.8 IMPACTS OF DEVELOPMENT ON THE ENVIRONMENT

Over the years, in the name of development, man has been unscrupulously exploiting the environmental resources and which, in turn, has resulted in many adverse effects on air, water and land. The extent of impact is so much that it even threatens the very existence of life on earth.

1.8.1 Environmental Impacts of Urbanization

Table 1.2 shows a list of adverse effects of urbanization on the various environmental components such as atmosphere, hydrosphere and lithosphere.

Table 1.2 *Environmental Impacts of Urbanization*

Environmental component	*Population (numbers and density)*	*Urban component*		
		Land use	*Transportation*	*Services*
Atmosphere	Increased release of CO_2, decreased O_2 production, as plant colonies are destroyed by spreading urban areas.	Increased average temperature for most urbanized areas.	Air pollution from combustion of fuel creation of photo-chemical smog.	Particulate matter and noxious fumes from incinerators, landfills and sewage treatment plants.
Hydrosphere	Greater demand on water resources (both surface and ground water).	More intense use of hydrologic resources causing increased pollution.	Rain and surface waters polluted with lead. Drainage patterns altered by infrastructure.	Leaching of pollutants from landfills. Discharges from sewage outfalls pollution from boats.
Lithosphere	Increased transformation of uninhabited agricultural or unutilized land to urban uses.	Complete changes due to construction, landscaping, etc.	Disruption or disfigurement of landscape, etc.	Sanitary landfill of urban wastes and installation/repairs of services disturb landscape.

Causes, effects and management options for various environmental problems related to air, water and land are listed in Table 1.3.

Table 1.3 *Summary of Urban Environmental Issues and Options*

Problem area	Effects	Causes	Management options
Ambient air pollution	■ Health problems ■ Economic costs from healthcare costs and productivity losses ■ Amenity losses (aesthetic, cultural, and recreational)	■ Industrialization ■ Increase in motorized fleet and congestion ■ Use of highly polluting fuels ■ Energy pricing policies ■ Topography and climate	■ Fuel pricing ■ Regulations, standards, emissions charges ■ Demand management ■ Transport planning ■ Appropriate technology (clean fuels, air pollution control equipment, etc.)
Indoor air pollution	■ Health problems (chronic obstructed lung disease, acute respiratory infections, low birth weights, cancer) ■ Economic costs from healthcare and productivity losses	■ Use of low-quality fuels for cooking and heating (biomass and high sulphur coal) ■ Poorly ventilated dwellings and workplaces ■ Passive smoking ■ Cottage industry activities	■ Substitution of fuel and equipment pricing ■ Fuel switching ■ Building codes ■ Public education ■ Tax hazardous products and processes
Surface water pollution	■ Health problems ■ Economic costs (additional treatment, new sources of supply, health costs) ■ Amenity losses	■ Pricing policies ■ Poor regulations and/or enforcement ■ Municipal and industrial waste disposal practices ■ Urban runoff ■ Irrigation practices	■ Regulations, standards, licensing, charges ■ Improve monitoring and enforcement ■ Demand management and wastewater reuse ■ Appropriate technology ■ Land use controls ■ Waste management
Groundwater pollution depletion	■ Reduced water quality from saline intrusion ■ Health impacts ■ Economic costs	■ Pricing policies ■ Poor regulations and/or enforcement ■ Unsustainable extraction ■ Sanitation, municipal and industrial waste disposal practices ■ Poor demand management	■ Regulation, standards, licensing charges ■ Waste management ■ Appropriate technology (rain water harvesting) ■ Demand management ■ Controls on land use and sources of infiltration

(*Contd.*)

Table 1.3 *(Contd.)*

Problem area	Effects	Causes	Management options
Coastal/lake pollution	■ Health effects due to contaminated seafood and direct contact ■ Loss of recreational resources and tourism revenues ■ Damage to fisheries ■ Amenity losses ■ Eutrophication	■ Unclear property rights ■ Poor regulations and/or enforcement ■ Municipal and industrial waste disposal practices ■ Disposal of shipboard wastes	■ Regulations, standards, licensing charges ■ Appropriate technology ■ Coastal zone management and preservation ■ Shipping facilities ■ Waste management ■ Land use control
Degradation of land	■ Declining agricultural productivity ■ Reduced renewable resource base (deforestation, lost soil fertility) ■ Erosion and siltation ■ Amenity losses ■ Loss of natural habitat and species	■ Changes in relative value of land uses ■ Uncontrolled urban growth ■ Unclear property rights ■ Mining and quarrying activities ■ Land disposal of municipal and industrial wastes	■ Internalize ecological value in land prices ■ Designate special areas for management ■ Local participation ■ Clarify property rights ■ Economic resource pricing ■ Land use controls
Loss of cultural and historical property	■ Loss of heritage ■ Loss of tourism revenues ■ Damage to culturally values buildings, monuments, natural sites	■ Lack of regulation and/or enforcement ■ Air pollution ■ Land subsidence and poor drainage	■ Internalize costs of loss in redevelopment planning ■ Tax incentives for preservation ■ Zone and building codes ■ Pollution control
Degradation of ecosystems	■ Health hazards ■ Resettlement costs ■ Loss of habitat and species ■ Air, water, and land pollution	■ Failure to anticipate effects in planning and development ■ Pricing policies ■ Lack of rural political power	■ Public education ■ Internalize costs of rural degradation ■ Resource pricing ■ Clarify property rights
Municipal solid wastes	■ Household costs related to blocked drainage and flooding ■ Water pollution from leachates ■ Air pollution from burning ■ Amenity losses	■ Poor management (improper collection and disposal, little resource recovery) ■ Pricing (no cost recovery) ■ Disposal impacts external to the community ■ Input pricing ■ Expanded coverage	■ Private sector delivery of collection and disposal ■ Waste minimization (recycling, recovery, source reduction) ■ Regulations, standards, licensing, charges ■ Institutional strengthening

(Contd.)

Table 1.3 *(Contd.)*

Problem area	Effects	Causes	Management options
Hazardous wastes	■ Surface, ground, coastal water contamination ■ Related health, economic and resource impacts ■ Accumulation of toxics in the food chain ■ Reduced property values	■ Inadequate regulations and/or enforcement ■ No incentives for treatment ■ Input pricing for waste-producing industries ■ Low visibility, nonlinear, long-term effects ■ Dispersed small-scale and cottage industries	■ Regulations, standards, licensing and standards ■ Improve monitoring and enforcement ■ Treatment and disposal incentives ■ Economic input pricing ■ Waste minimization ■ Marginal cost pricing ■ Special incentives for small-scale generators ■ Privatization of treatment and disposal operations
Natural and man-made hazards	■ Health effects (death, injuries) ■ Economic costs (loss of lives, property, infrastructure) ■ Land degradation (flooding, landslides, earthquakes) ■ Amenity losses	■ Natural forces ■ Land market failures (lack of alternatives for squatters, artificially constrained supply) ■ Land policies (no taxation, no/unenforced protection of high risk lands) ■ Poor construction practices	■ Reduce constraints on supply of usable land ■ Appropriate incentives (prices, taxes, tenure, housing finance) ■ Land use controls ■ Improve knowledge about risks and alternatives
Inadequate sanitation	■ Health impacts (diarrhoeal diseases, parasites, high infant mortality, malnutrition) ■ Related economic costs ■ Eutrophication ■ Amenity losses	■ Inappropriate technology ■ Pricing (no cost recovery) ■ Poor management (lack of operations and maintenance, uncoordinated investments) ■ Inadequate hygiene education	■ Gear sanitation options to willingness to pay ■ Community approaches ■ Cost recovery ■ Hygiene education
Inadequate drainage	■ Health effects ■ Property damage ■ Accidents ■ Reduced urban productivity (shutdown of business, transport systems)	■ Inadequate hygiene education ■ Increased urban runoff due to impermeabilization and upstream deforestation ■ Occupation of low-lying lands	■ Community management of maintenance ■ Strategic investment in drainage ■ Land use controls and market liberalization ■ Solid waste management

Table 1.4 *Pros and Cons of Biofuels*

Biofuels	
Pros	***Cons***
Promoted as a planetfriendly, renewable source of energy.	Critics argue that biofuel production takes valuable agricultural land.
Substitute for coal and oil.	Sugarcane cultivation encroaches on wildlife habitat, degrades soil and causes pollution when fields are burned.
Burn cleaner and produce less greenhouse gas than fossil fuels.	Causes destruction of rain forests.
Farmers can produce them domestically, reducing dependence on foreign sources of oil.	About 70% more energy is required to produce ethanol than the energy that actually is in ethanol.

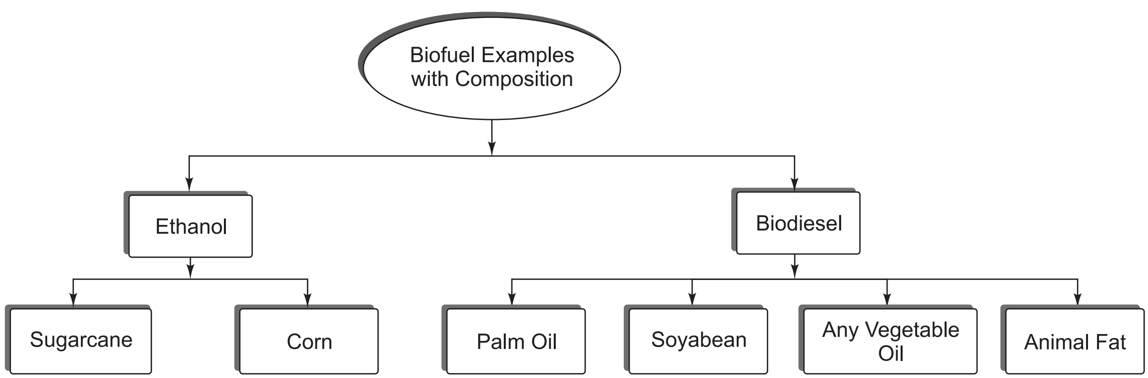


Fig. 1.8 *Composition and Examples of Biofuel*

REVIEW QUESTIONS

Objective-Type Questions

1. Who is the author of the book 'Silent Spring'?

(a) Robin Cook (b) Arthur Hailey

(c) Rachel Carson (d) Charles Darwin

2. DDT is
(a) not soluble in water
(b) more soluble in fat than water
(c) less soluble in fat than water
(d) not soluble in fat

3. Which of the following scientists rediscovered DDT in 1939?
(a) Paul Hermann Müller
(b) Madam Curie
(c) Rachel Carson
(d) Alexander Fleming

4. POPs is
(a) Persistent Oxidizing Pollutants
(b) Permanent Organic Pesticides
(c) Persistent Organic Pesticides
(d) Persistent Organic Pollutants

5. Who proposed the Gaia theory?
(a) Rachel Carson
(b) James Lovelock
(c) Charles Darwin
(d) William Golding

6. The objective of environmental education is
(a) to raise consciousness about environmental conditions
(b) to teach environmentally appropriate behaviour
(c) to create an environmental ethic that fosters awareness about the ecological inter-dependence of economic, social and political factors in a human community and the environment
(d) all of the above

7. Which of the following is not influenced by human activities?
(a) Depletion of ground water
(b) Destruction of mangroves and wetlands
(c) Increased extinction rates of species
(d) None of the above

8. The Stockholm Convention on Persistent Organic Pollutants (POPs) was signed in the year
(a) 1999
(b) 1998
(c) 2000
(d) 2001

9. Which of the following statements about environmental education is false?
(a) Environmental education is evolving to be education for sustainable and ethical development both at local and global levels.
(b) Environmental education will prepare the next generation to plan appropriate strategies for addressing developmental environmental issues.

(c) Environmental education does not advocate a particular viewpoint or course of action.
(d) Environmental education is essential for the younger generation only.

10. Which of the following conceptual spheres of the environment is having the least storage capacity for matter?
(a) Atmosphere (b) Lithosphere
(c) Hydrosphere (d) Biosphere

11. Which of the following components of the environment are effective transporters of matter?
(a) Atmosphere and hydrosphere (b) Atmosphere and lithosphere
(c) Hydrosphere and lithosphere (d) Lithosphere and hydrosphere

12. Which of the following one is not related to the loss of productivity of croplands?
(a) Desertification (b) Waterlogging
(c) Salt buildup in topsoil (d) None of the above

13. Biosphere is
(a) the solid shell of inorganic materials on the surface of the earth
(b) the thin shell of organic matter on the surface of the earth comprising all the living things
(c) the sphere which occupies the maximum volume of all the spheres
(d) all of the above

14. Which of the following is an example of impact of developmental activities on the hydrosphere?
(a) Air pollution (b) Soil pollution
(c) Soil erosion (d) Water pollution

15. Global atmospheric temperatures are likely to be increased due to
(a) burning of fossil fuels (b) water pollution
(c) soil erosion (d) none of the above

16. Which of the following is a management option for air pollution?
(a) Regulations and standards (b) Emission charges
(c) Transport planning (d) All of the above

Short-Answer Questions

1. What are the factors that have led to the increased resource consumption on earth in recent years?

2. Define the term "environment".
3. What are the major objectives of environmental education?
4. Define environmental literacy.
5. List the instances pointing to the fact that humans have significantly affected the earth's natural systems.
6. What is the role of science and engineering in the protection of the environment?
7. Why is it beneficial to follow a student-centered and participatory process for environmental education?
8. List the pesticides polluting the environment in your locality.
9. Why is the ban on DDT not imposed in certain parts of the world?
10. List the four conceptual spheres in the earth's environment.
11. Differentiate between biosphere and lithosphere.
12. What are the impacts of urbanization on atmosphere?
13. Differentiate between conveyor and reservoir.
14. What are the impacts of urbanization on hydrosphere?
15. List the causes, effects and management options for the following environmental issues.
    - Air pollution
    - Water pollution
    - Land degradation
    - Loss of cultural and historical property
    - Degradation of ecosystems
    - Municipal solid waste management
    - Hazardous waste management
    - Inadequate drainage and sanitation

Descriptive Questions

1. Explain the importance of environmental education in the present-day context.
2. Explain the scope of environmental engineering.
3. 'Knowledge about the environment is not an end, but rather a beginning.' Explain.
4. List the types of environmental engineering taking place around your locality and analyze its root causes.
5. Explain the scope of environmental engineering.

6. With the help of a neat sketch, explain the flow of matter among the various components of the environment.
7. Explain the role of human beings in the grand-scale redistribution of chemicals on earth.
8. List the major urban environmental issues in India.
9. Explain the components of environment and their major interactions.
10. Explain the impact of urbanization on the environment.
11. Explain the causes, effects and management options for the various urban environmental issues.
12. What are the impacts of urbanization on the air quality in your locality?
13. What are the major obstacles in maintaining air quality in your locality?
14. Explain the impact of land use changes on the water quality of your nearest river.
15. If environmenal degradation is considered as a side-effect of development, express your views on the current pattern of development activities in India.
16. 'Biofuel is a cure worse than the disease.' Comment on the statement.
17. Conduct a survey and find out how chemicals and various materials are distributed/cycled in your campus.

Answers to Objective-Type Questions

1. (c)	2. (b)	3. (a)	4. (d)	5. (b)	6. (d)	7. (d)
8. (c)	9. (d)	10. (a)	11. (a)	12. (d)	13. (b)	14. (d)
15. (a)	16. (d)					

NATURAL RESOURCES

" Adopt the pace of nature: her secret is patience."

Ralph Waldo Emerson

Learning Outcomes

On successful completion of this chapter, students will be able to:

- Demonstrate an understanding of the significance of forest resources and the major threats to it such as mining and dams.
- Summarize the water resources of the planet and discuss the topics such as drought and conflicts over water.
- Explain the terms Food Resources and Food Security in the context of modern-day agriculture.
- Compare and contrast various energy resources.

2.1 FOREST RESOURCES

Due to rapid urbanization, the area of forest is decreasing all over the world. The protection of forest resources is essential for the survival of our species. This section explains the components, benefits and uses of forest to underline the necessity of protection of forest resources.

Figure 2.1 depicts the various living and non-living components of a natural forest.

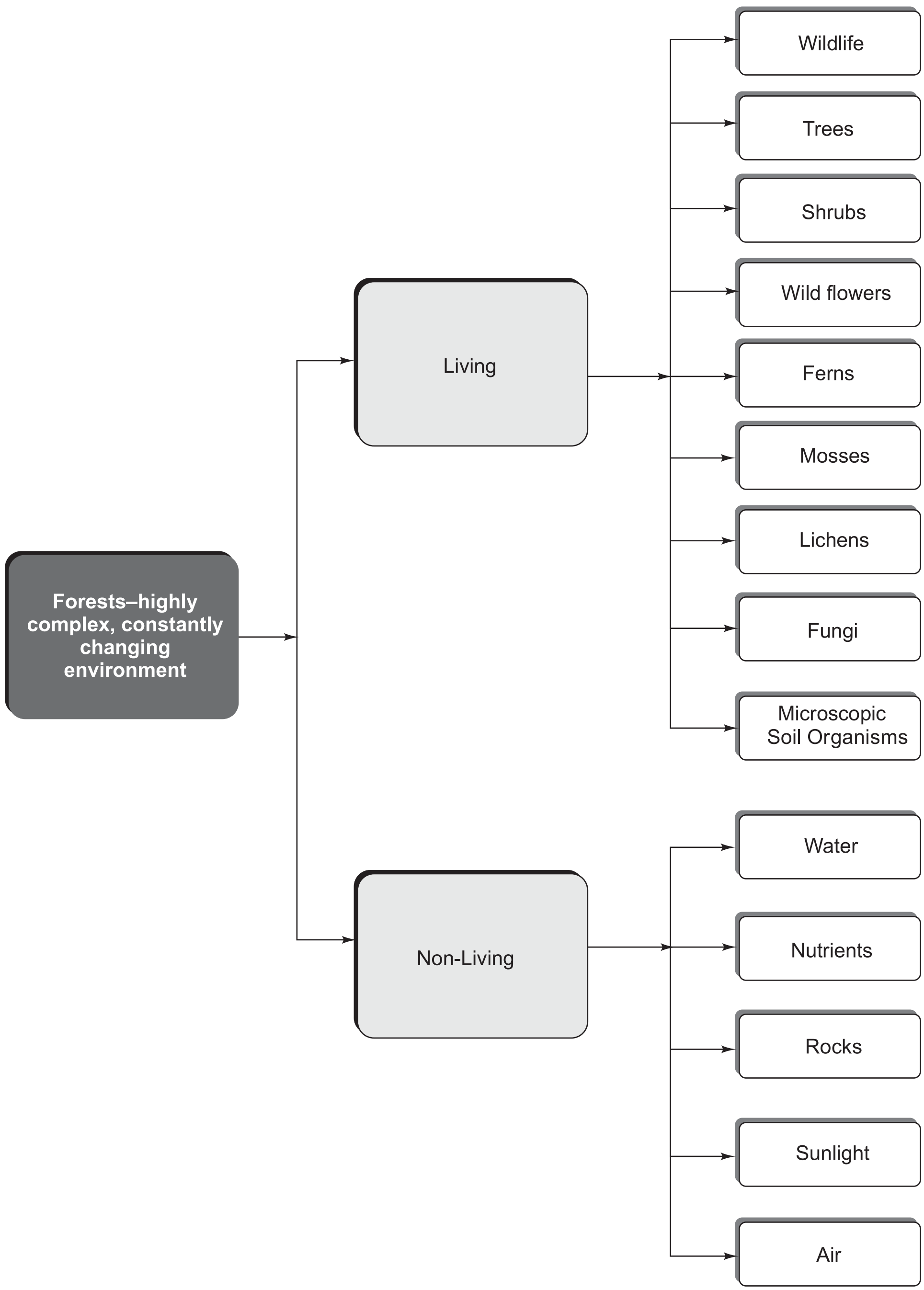


Fig. 2.1 *Components of Forest*

2.1.1 Key Benefits of Intact Forests

The following is a list of key uses and benefits of intact forests.

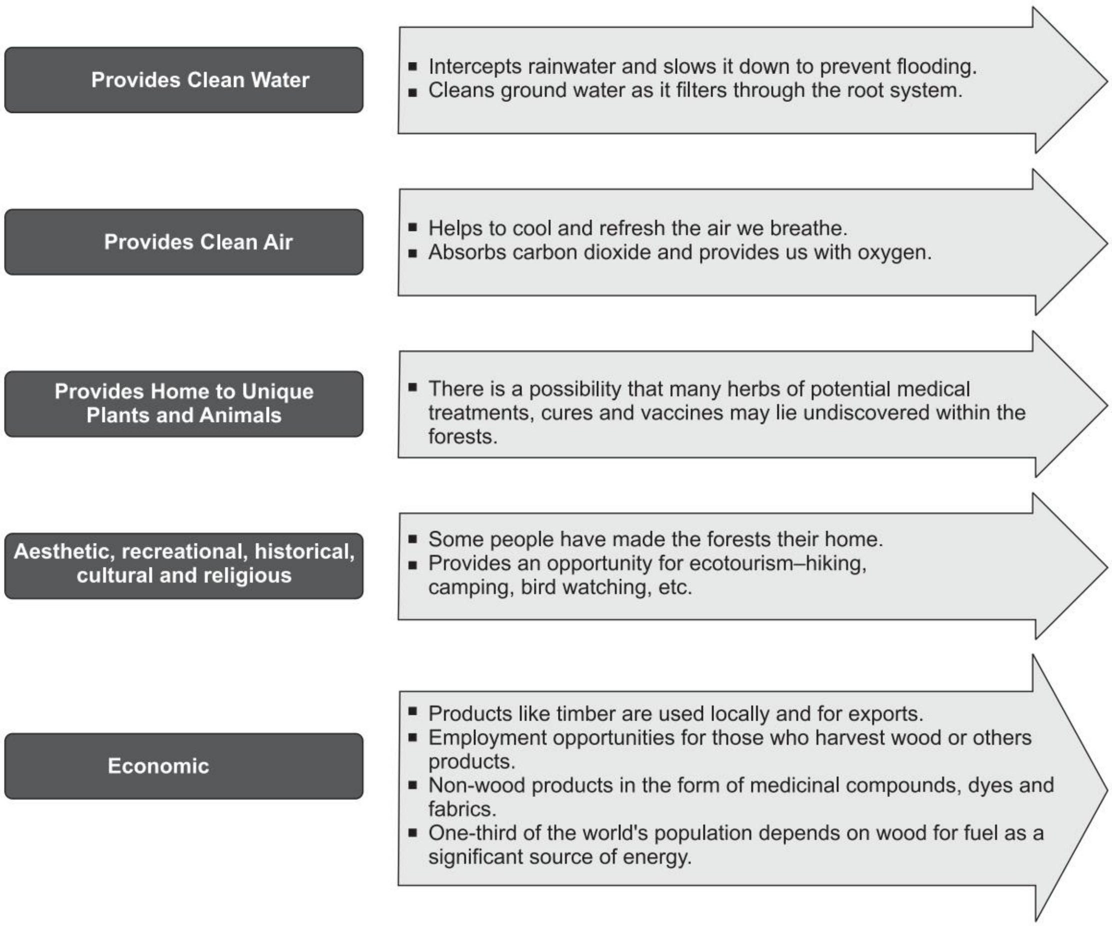


Fig. 2.2 *Some Uses and Benefits of Forests for Humans*

2.1.2 Deforestation

Deforestation refers to the loss of forest cover; land that is permanently converted from forest to agricultural land, golf courses, cattle pasture, homes, lakes, or desert. The depletion of forest tree crown cover less than 90% is considered forest degradation. Logging most often falls under the category of forest degradation and thus is not included in deforestation statistics. Therefore forest degradation rates are considerably higher than deforestation rates.

If the current rate of deforestation continues, the world's forests will vanish within the next 100 years—causing unknown effects on global climate and eliminating the majority of plant and animal species on the planet.

2.1.3 Causes of Deforestation

The causes of deforestation are very complex. A competitive global economy drives the need for money in economically weak developing countries. At the national level, governments sell timber to raise money for projects, to pay international debt, or to develop industry.

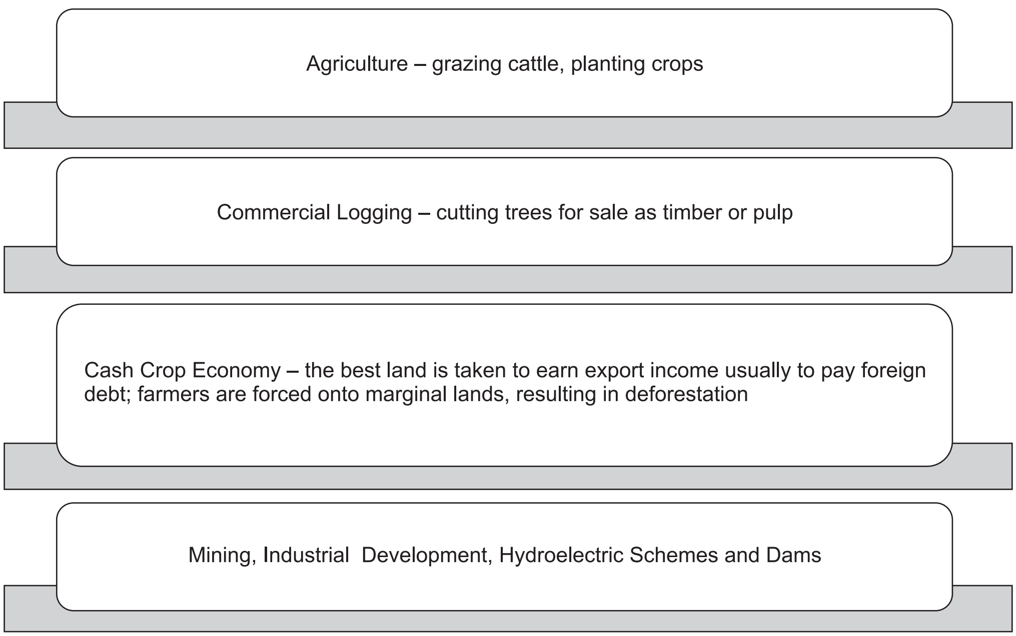


Fig. 2.3 *Major Causes of Deforestation*

2.1.4 Effects of Deforestation

Since many people are dependent on the world's forests, deforestation will have many social, economic and ecological effects. The major effects of deforestation on the environment are classified and illustrated in Fig. 2.4.

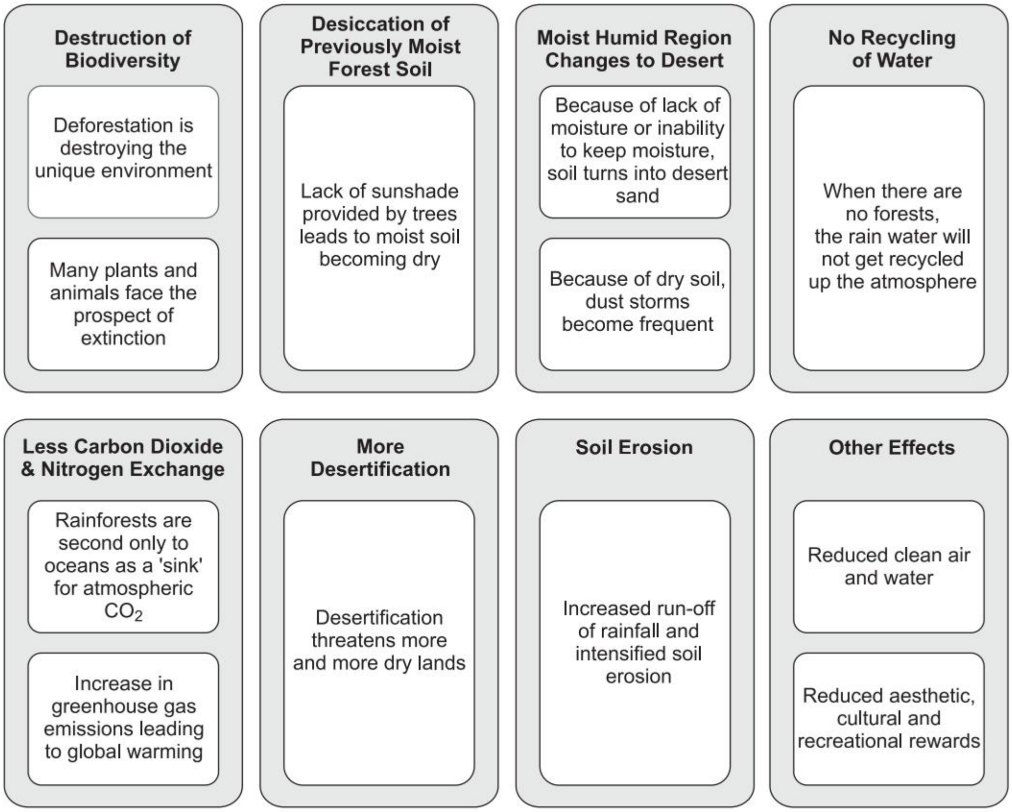


Fig. 2.4 *Environmental Effects of Deforestation*

2.1.5 Solutions to the Problems of Deforestation

Deforestation is a serious problem, but humans can make a difference. An individual as well as a society can practice green consumerism. The following actions could serve as effective solutions to the problem of deforestation.

- Reduce the consumption of forest and related products.
- Avoid harmful products by consumer boycotts, such as tropical rainforest wood, old-growth wood from the tropical rainforest.
- Boycott products of companies involved in deforestation.
- Compel government and industry to make changes in the forest policies.
- Individuals may communicate their uncertainty about the future of the world's forests to politicians, corporate executives and non-governmental organizations through personal communication or in groups using petitions and rallies.
- Environmental conservation may be given importance in school curricula.

In 1988, the Government of India introduced a new forest policy that called for significant change in the management of forest land. The draft National Forest Policy 2016 continues with the national goal of maintaining a minimum of one-third of the geographical area under forest or tree cover.

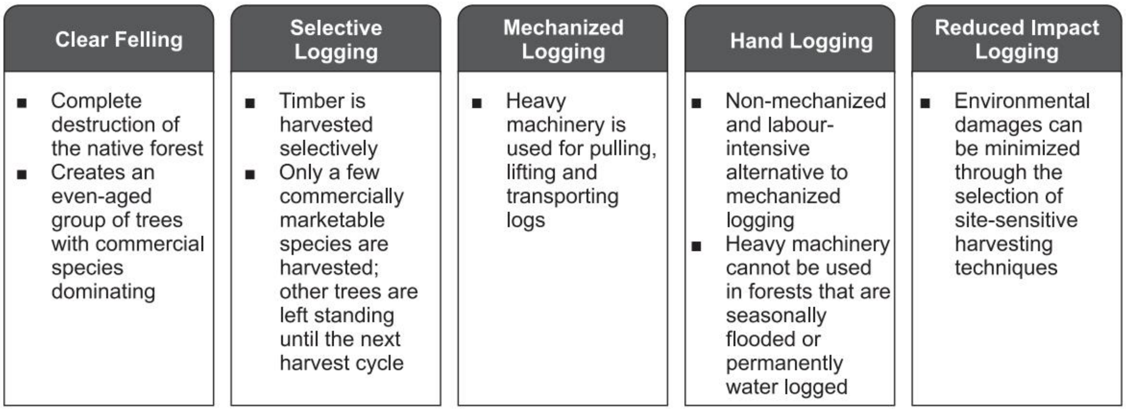


Fig. 2.5 *Types of Timber Extraction*

2.1.6 Mining

Mining is the act of extracting ores, coal, etc. from the earth. Mining on an industrial scale can produce environmental damages resulting from exploration and development, even long after the mine is closed. The following is a list of adverse impacts of mining on forests and the environment.

- Mining, especially open-pit mining, generates enormous quantities of waste compared to any other natural resource extraction activity. Water interacts with these wastes to generate contaminated fluids that can pollute soils, rivers, and ground water.
- Erosion and sedimentation present another environmental issue for mine sites.
- Increased access to otherwise remote forest areas and provide an opportunity for further activities, especially in places where population pressures already exist.
- Dust generated from mining activities can cause air pollution, a serious cause of illnesses, generally in the form of respiratory troubles in people and asphyxia of plants and trees. Furthermore, usually, release of gases and toxic vapour takes place.
- Mining activities consume enormous quantities of timber for their construction and as a source of energy. Mining activities imply major works such as road building, ports, mining villages, deviation of rivers, construction of dams and energy generating plants.

- The deafening sound of the machinery used in mining and the blasting create conditions that may become unbearable for the local population and the forest wildlife.
- The large disturbances caused by mining can disrupt environments, adversely affecting aquatic habitats (i.e. lakes, ponds, streams, rivers), terrestrial habitats (i.e. deserts, grasslands, forests), and wetlands that many organisms rely on for survival.
- As large-scale mining creates new infrastructure and provides additional employment, permanent settlements can arise around these operations in areas that otherwise would have remained more sparsely inhabited. Mining comes along with its promise of wealth and jobs, but millions of people throughout the whole world testify to the high social costs that it brings with it. The following is a list of the negative social impacts of mining.
  - Appropriation of the land belonging to the local communities
  - Impacts on health
  - Alteration of social relationships
  - Destruction of forms of community subsistence and life
  - Social disintegration
  - Radical and abrupt changes in regional cultures
  - Displacement of other present and/or future local economic activities.

2.1.7 Mineral Resources of India

India has a large number of economically useful minerals and they constitute one-quarter of the world's known mineral resources. About two-thirds of its **iron deposits** lie in a belt along Orissa and Bihar border. Other haemaite deposits are found in Madhya Pradesh, Karnataka, Maharashtra and Goa. Magnetite iron-ore is found in Tamil Nadu, Bihar and Himachal.

Table 2.1 shows the location of various mineral resources of India.

Table 2.1 *Location of mineral resources of India*

Mineral Belt	*Geographic Location*	*Minerals Found*
North Eastern Peninsular Belt	The region comprising the Chota Nagpur plateau and the Orissa plateau which covers the states of Jharkhand, West Bengal and Orissa.	Manganese, bauxite, copper, coal, iron ore, mica, kyanite, chromite, beryl, apatite etc.

(*Contd.*)

Table 2.1 *(Contd.)*

Mineral Belt	*Geographic Location*	*Minerals Found*
South Western Belt	Karnataka and Goa	Garnet iron ore and clay.
North Western Belt	Rajasthan and Gujarat along the Aravali Range	Mostly non-ferrous minerals, uranium, aquamarine, petroleum, mica, beryllium, gypsum and emerald.
Southern Belt	Karnataka plateau and Tamil Nadu	Bauxite and ferrous minerals
Central Belt	Andhra Pradesh, Chhattisgarh, Madhya Pradesh and Maharashtra	Bauxite, uranium, manganese, limestone, mica, graphite, marble, coal, gems, etc.

2.2 DAMS

It can be unequivocally stated that dams have made a significant contribution to human development.

2.2.1 Dams and Civilization

Men have built dams for thousands of years for:

- Conversion of available water to usable water.
- Reducing variability in seasons of low flow in rivers.
- Water storage to provide insurance against uncertainty in natural water availability due to climatic variability.
- Regulating release of water for various uses such as drinking and irrigation.
- Safety from social and economic tragedies due to flood and drought conditions.
- Sustainable energy generation.

2.2.2 Purposes of Dams

- Most of the single purpose dams around the world (48% approx.) are for irrigation and therefore it contributes greatly to food production.
- For the world as a whole, nearly 20% of dams generate electricity. However, in Europe alone, about 40% are hydro power dams.
- Other purposes include flood control, recreation and to a lesser degree, inland navigation and fish farming.
- Multi-purpose dams account for a large proportion. Irrigation comes first in this category also, followed by flood control, hydro power, domestic and industrial water supply and recreation, with fish farming and navigation.

- In India, more than 80% of the rain occur during monsoon. We still need large dams to store the excess water.

2.2.3 Benefits of Dams

- 40% of world food production comes from irrigated farming, with a direct 16% contribution from land irrigated from dam reservoirs.
- Hydro-electric power produces 19% of world energy.
- Large dams supply towns and cities with water.
- Dams help control river floods and flooding.
- Some dams have helped improve ecosystems by creating new wetlands and new opportunities for fishing and recreation in the reservoirs.

2.2.4 Problems with Dams

- Many large dams have typically fallen short of physical targets, did not recover their costs and have been less profitable in economic terms than expected.
- The impacts of large dams on ecosystems are more negative than positive and in many cases, this has led to serious irrecoverable loss of species and ecosystems.
- They have displaced large numbers of people, who, when resettled, have been unable to recover acceptable conditions of existence.
- The loss of forests and wildlife habitat and the degradation of upstream catchment areas due to inundation of the reservoir area.
- The loss of aquatic biodiversity, of upstream and downstream fisheries, and of the services of downstream floodplains, wetlands, and riverine, estuarine and adjacent marine ecosystems.
- Cumulative impacts on water quality, natural flooding and species composition where a number of dams are sited on the same river.
- Sedimentation and the consequent long-term loss of storage is a serious concern globally.
- Waterlogging and salinity affect one-fifth of irrigated land globally (including land irrigated by large dams).

2.2.5 Socio-economic Impacts of Dams

- Poorly managed involuntary displacement and loss of livelihood.

- Many of the displaced people were not recognized and therefore were not resettled or compensated.
- Depriving the indigenous people of the means to support traditional ways of life.
- Higher incidences of waterborne diseases.
- Low regional economic development reforms and inadequate distribution of project benefits to affected communities.
- It is not possible to mitigate many of the impacts of reservoir creation on terrestrial ecosystems and biodiversity.
- The use of fish passes to mitigate the blockage of migratory fish has had little success.
- Millions of people living downstream from dams (particularly those depending on natural flood plain function and fisheries) have also suffered serious harm to their livelihoods.
- Those who were resettled rarely had their livelihoods restored, as resettlement programmes have focused on physical relocation rather than the economic and social development of the displaced.

2.2.6 Controversy on Hydropower

In addition to the water they provide, dams also provide energy in the form of hydroelectric power. An increased understanding of the effects of large-scale inundations of dam waters has caused concerns about the reliability and cleanliness of hydropower.

- Hydropower plants are often unsustainable in countries where frequent droughts cripple power production.
- In general, hydropower produces little carbon dioxide, except for cement and steel used in construction. However, large, shallow reservoirs, especially in the tropics, can generate large amounts of greenhouse gases from the decay of biomass from it.
- Historically, planners of large dams have ignored numerous additional cost factors, including potential structural difficulties, human resettlement costs, and environmental consequences and the capital cost.
- Siltation can reduce dam capacity, thereby diminishing power generating capacity, or deplete downstream farmlands.
- One of the most serious charges against hydropower, though it applies to all dams, is its high social cost in terms of involuntary resettlement.

2.2.7 Possible Solutions to Improve the Acceptability of Dam Projects

Public acceptance of key decisions is essential for equitable and sustainable water and energy resources development. Acceptance emerges from recognizing rights, addressing risks, and safeguarding the entitlements of all groups of affected people, particularly indigenous and tribal peoples, women and other vulnerable groups.

2.3 WATER RESOURCES

The world's supply of fresh water is running out. According to a UNICEF and WHO update on drinking water and sanitation (2012), one person in five has no access to safe drinking water. The amount of water in the world is limited. Even though water covers about two-thirds of the Earth's surface, most of it is too salty for use. The World Water Council believes that by 2020 we shall need 17% more water than is available to feed the world. The major factors worsening the present water crisis are the following.

- Growing populations
- Inefficient irrigation
- Pollution

Some Water Facts

- Global consumption of water is doubling every 20 years.
- Available fresh water amounts to less than one-half of 1% of all the water on earth.
- Fresh water is renewable only by rainfall at the rate of only 40 000–50 000 km^3 per year.
- If the current trends continue, by 2025 the demand for freshwater is expected to rise by 56% more than is currently available.
- The United Nations reports that currently 31 countries face water stress and scarcity.
- Throughout the world, more than one billion people drink unsafe water. Two point four (2.4) billion people, 40% of the human race are without adequate sanitation and 3.4 million people, mostly children, die every year of water-related diseases.
- By 2025 it is predicted that two-thirds of the world's population will be living in conditions of serious water shortage. One-third will be living in conditions of absolute water scarcity.
- The world's quest for freshwater has led to widespread environmental destruction. The number of large dams built to divert water has risen from 5,000 in 1950 to

45000 today. The environmental impact resulting from such diversions has been devastating.

- Only 2% of the continental US rivers and streams remain free flowing, they have lost over 50% of that country's wetlands.
- Every 8 seconds, a child dies from a water-related disease.
- 50 per cent of people in developing countries suffer from one or more water-related diseases.
- 80 per cent of diseases in the developing world are caused by contaminated water.
- 50 per cent of people on earth lack adequate sanitation.
- 20 per cent of freshwater fish species have been pushed to the edge of extinction due to contaminated water.

2.3.1 Drought

Drought is a complex physical and social process of widespread significance. It is not usually a countrywide phenomenon, with differing conditions in the country often making drought a regional issue. Despite all of the problems that droughts have caused, drought has proven to be difficult to define and there is no universally accepted definition. Figure 2.6 shows the characteristics of various types of droughts.

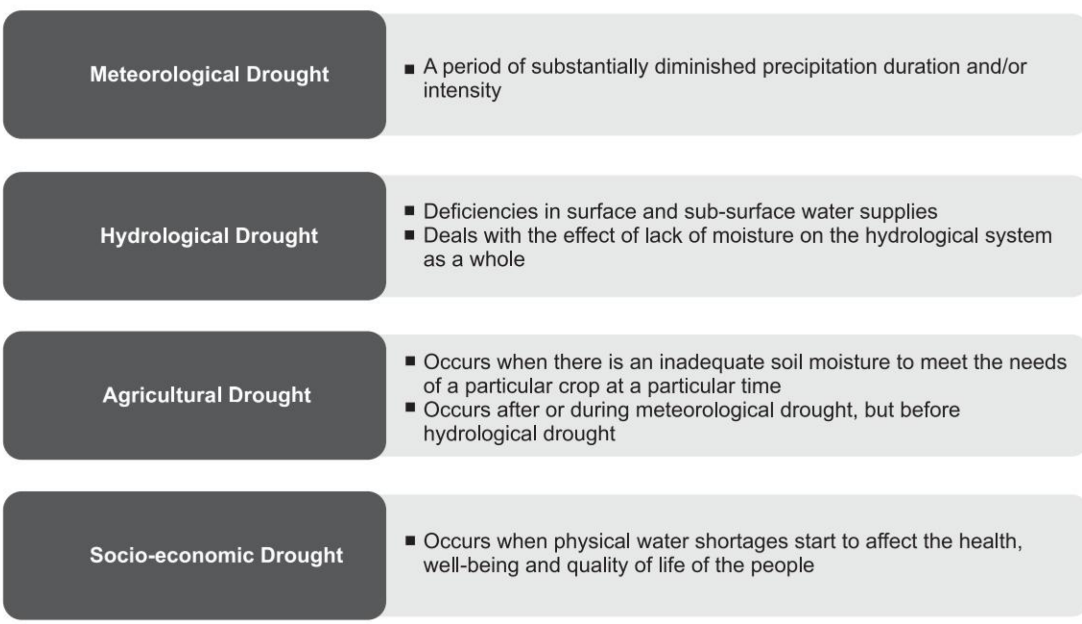


Fig. 2.6 *Characteristics of Various Types of Droughts*

2.3.2 Conflicts Over Water

The conflicts over water around the world may be classified into the following categories.

1. ***Control of water resources***, where water supplies or access to water is at the root of tensions.
2. ***Military tool***, where water resources, or water systems themselves, are used by a nation or state as a weapon during a military action.
3. ***Political tool***, where water resources, or water systems themselves, are used by a nation, state, or a group for a political goal.
4. ***Terrorism***, where water resources, or water systems, are either targets or tools of violence or coercion by terrorists.
5. ***Military target***, where water resource systems are targets of military actions by nations.
6. ***Development disputes***, where water resources or water systems are a major source of contention and dispute in the context of economic and social development.

2.4 FOOD RESOURCES

2.4.1 Global Food Problems

The world agricultural sector on an average has kept up with population growth and demand for food and agricultural produce.

Despite the availability of viable technologies to increase food and agricultural production, economic and social progress is not occurring at similar rates across countries. This is because many of the poorer countries are unable to be self-sufficient in food and agricultural production due to various economic, social, and political constraints.

According to the authoritative Consultative Group on International Agricultural Research (CGIAR), the world is entering the 21st century on the brink of a new world food crisis that is as dangerous, but far more complicated than the threats it faced in the 1960s.

Some analysts believe that what is needed is a new and greener revolution to once again increase productivity and boost production.

2.4.2 Food Security

Food security is the ability of all people at all times to access enough food for an active and healthy life. The following three conditions must be fulfilled to ensure food security:

- Food must be available.
- Each person must have access to it.

❍ The food utilized must fulfil nutritional requirements.

Food insecurity is not just a problem related to food production; it is closely linked to poverty and economic stagnation. The persistence of widespread food insecurity underscores the futility of increasing production without addressing the underlying social, political, and economic structures that make or keep people poor and hungry. One obviously must look beyond farm size, cultivable land use, population in food consumption, production, and distribution. In many instances, government policies have added to domestic food shortages, poverty, and income disparities in developing countries.

2.4.3 Adverse Effects of Modern Agriculture on Soil and Water Resources

In spite of the fact that modern agriculture practices are enabling us to keep up with the food demand of the world, modern agriculture comes up with its own share of environmental problems. Figure 2.7 illustrates the adverse effects of modern agriculture on soil and water resources.

Damage to Soil	▪ Soil erosion threatens the productivity of agricultural fields. ▪ Because it takes up to 300 years for one inch of agricultural topsoil to form, lost soil is irreplaceable.
Water Contamination	▪ Agriculture is the largest single non-point source of water pollutants including sediments, salts, fertilizers, pesticides and manures.
Water Scarcity	▪ Due to overuse of surface or groundwater for irrigation.
Global Climate Change	▪ Increased CO_2 and other greenhouse gases due to destruction of forests and native vegetation.
Waterlogging	▪ Occurs when soils are over irrigated. ▪ Too much water in the root zone of a plant because of which they cannot absorb enough oxygen to breathe and eventually die.
Soil Salinity	▪ When crops are over irrigated, the surplus water evaporates and the salts that are dissolved in it are left behind, increasing the soil salinity. This results in reduced plant productivity.

Fig. 2.7 *Adverse Effects of Modern Agriculture on Soil and Water Resources*

2.4.4 Problems with Fertilizers

Figure 2.8 illustrates the environmental problems associated with the overuse of chemical fertilizers in agriculture.

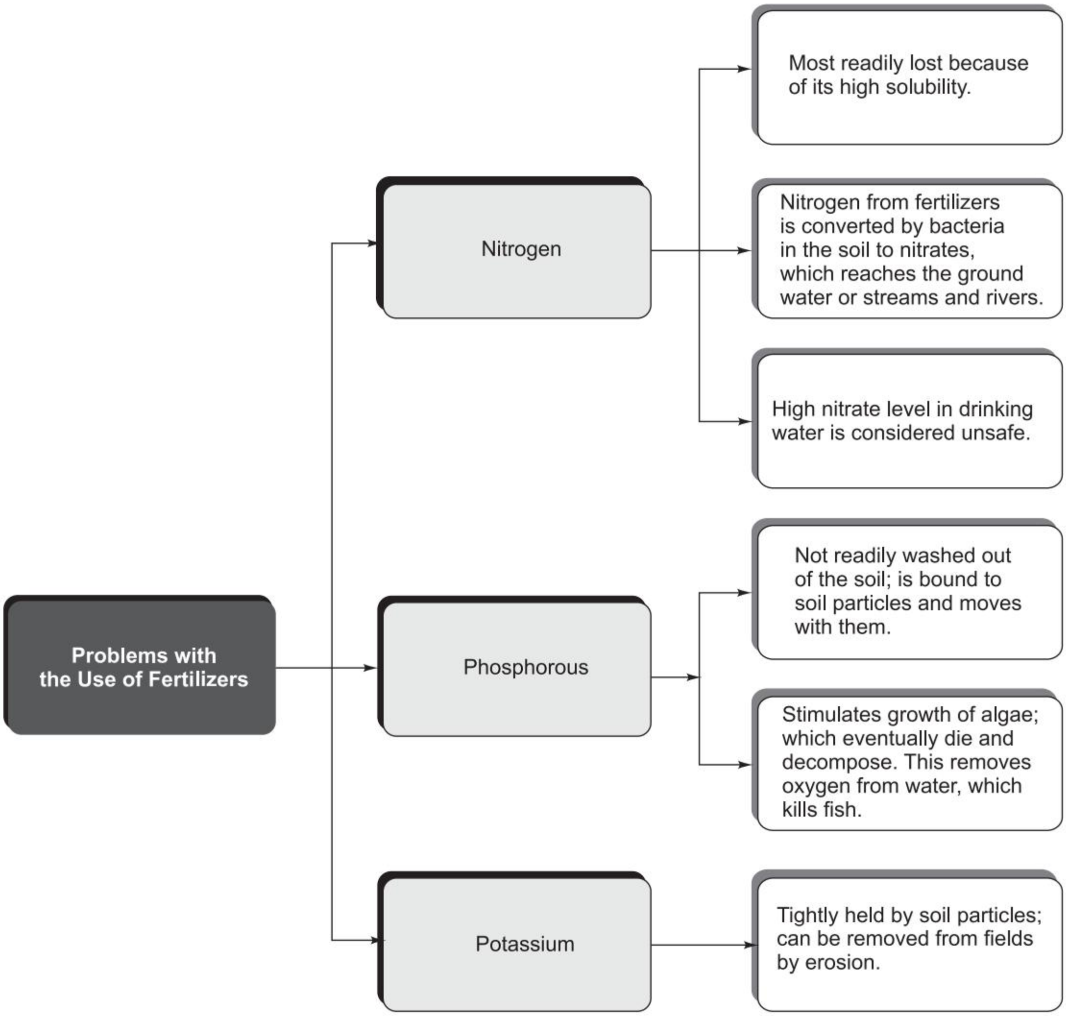


Fig. 2.8 *Problems with Fertilizers*

2.4.5 Pesticides

❑ *The ideal pesticide* The following are the qualities of an ideal pest-killing chemical.

- kills only the target pest,
- has no short- or long-term health effects on non-target organisms, including people,
- can be broken down into harmless chemicals in a fairly short time,
- prevents the development of genetic resistance in target organisms, and
- saves money compared to making no effort to control pest species.

Unfortunately, no known pest control chemical meets all these criteria.

❑ *Use of pesticides* Since 1945, chemists have developed many different types of synthetic organic chemicals for use as pesticides. Worldwide about 2.3 million metric tons of these pesticides are used each year on an average of 0.45 kilogram for each person on earth. About 85% of all pesticides are used in developing countries.

The supporters of pesticides believe that the benefits of pesticides outweigh their harmful effects. They point out the following benefits:

- **Pesticides save lives** by preventing deaths from insect-transmitted diseases such as malaria, bubonic plague, typhus and sleeping sickness.
- **They increase food supplies and lower food costs**.
- **They increase profits for farmers**—In the United States 42% of the annual potential food supply is destroyed by pests before and after harvest. The situation is not different in other parts of the world. Hence pesticides have the potential to increase the profits for farmers manifold.
- **They work faster and better than other alternatives**—Compared to alternative methods of pest control, pesticides can control most pests quickly and at a reasonable cost, have a relatively long shelf life, are easily shipped and applied and are safe when handled properly.
- **Safer and more effective products are continually being developed.**

❑ *The Problems of Pesticides—Development of Genetic Resistance* The most serious drawback to using chemicals to control pests is that most pest species, especially insects, can develop genetic resistance to a chemical poison through natural selection.

Because most pest species—especially disease organisms, have short generation time, a few surviving organisms can produce a large number of similarly resistant offspring in short time.

2.4.6 Alternative Methods of Insect Control

The opponents of the widespread use of pesticides argue that there are many safer, and in the long-run cheaper and more effective, alternatives to the use of pesticides by farmers. For centuries, farmers have used cultivation methods that discourage or inhibit pests. The following is a list of such practices.

- Crop rotation, in which types of crops planted in fields are changed from year to year so that population of pests that attack a particular crop don't have time to multiply to uncontrollable sizes.
- Planting rows of hedges or trees in and around crop fields to act as barriers to invasions by insect pests, provide habitats for their natural enemies, and serve as windbreaks to reduce soil erosion.
- Adjusting planting times to ensure that most major insect pests starve to death before the crop is available, or are consumed by their natural predators.
- Growing crops in areas where their major pests do not exist.
- Switching from monocultures to modernized versions of intercropping, agroforestry and polyculture that use plant diversity to help control pests.
- Destroy diseased or infected plants.

Artificial Selection, Crossbreeding, and Genetic Engineering Varieties of plants and animals that are genetically resistant to certain pest insects, fungi, and diseases can be developed.

2.4.7 Organic Agriculture

Organic agriculture is an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity. It is based on minimal use of off-farm inputs and on management practices that restore, maintain and enhance ecological harmony.

2.4.8 Advantages of Organic Fertilizers

- Organic fertilizers release nutrients slowly and usually contain many other trace elements that plants may need and which are not found in most chemical formulations.
- Fish emulsion, seaweed extracts and manure teas have a quick response as they are water soluble and instantly available to plants.
- They are not as concentrated as man-made fertilizers.
- Ecologically and environmentally safe—no toxins, no pollution.

- Provides a constant flow of amino acids and fatty acids where necessary.
- Restores the depleted vitamin and mineral content to the soil.
- Safe and easy to apply—no need for expensive protective clothing for applications.
- Eliminates environmental contamination—especially the surface water and in many areas, the underground water table.
- Provides the necessary soil microorganisms—these organisms assist with the manufacturing of organic matter and nitrogen fixation products that are very important to plant production and health.

2.5 ENERGY RESOURCES

All energy sources ultimately come from the sun, the moon or the earth. Figure 2.9 shows the various sources of energy.

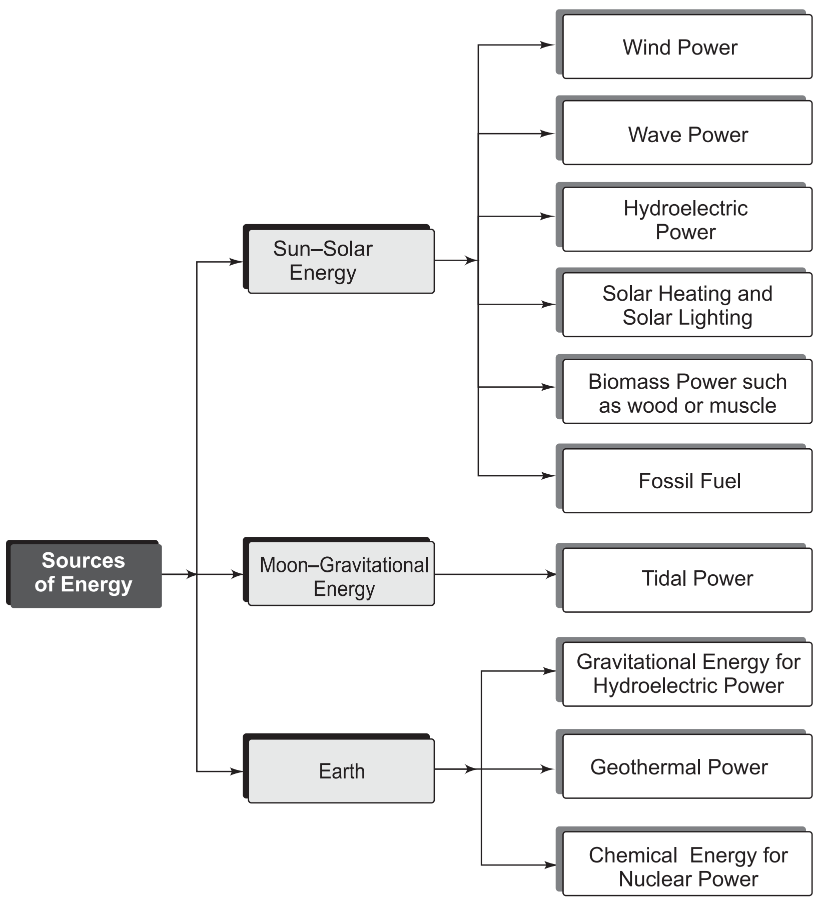


Fig. 2.9 *Sources of Energy*

2.5.1 Types of Energy

Figure 2.10 depicts the types of energy and Fig. 2.11 illustrates the major sources of energy.

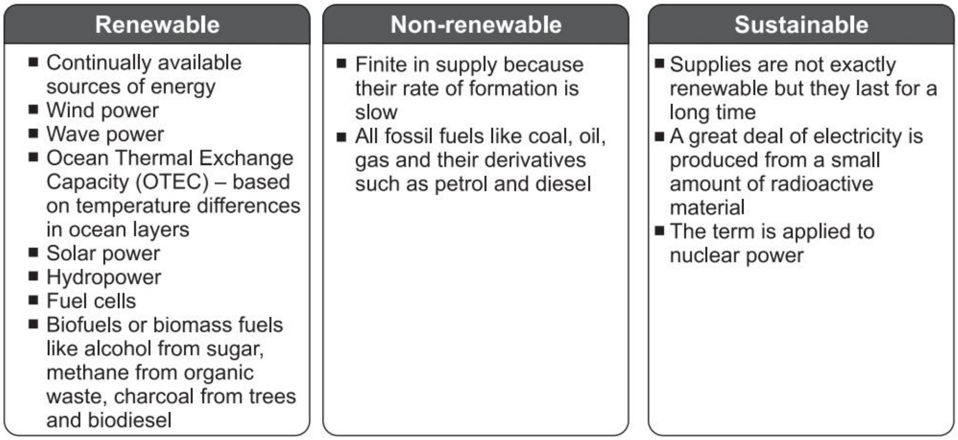


Fig. 2.10 *Types of Energy*

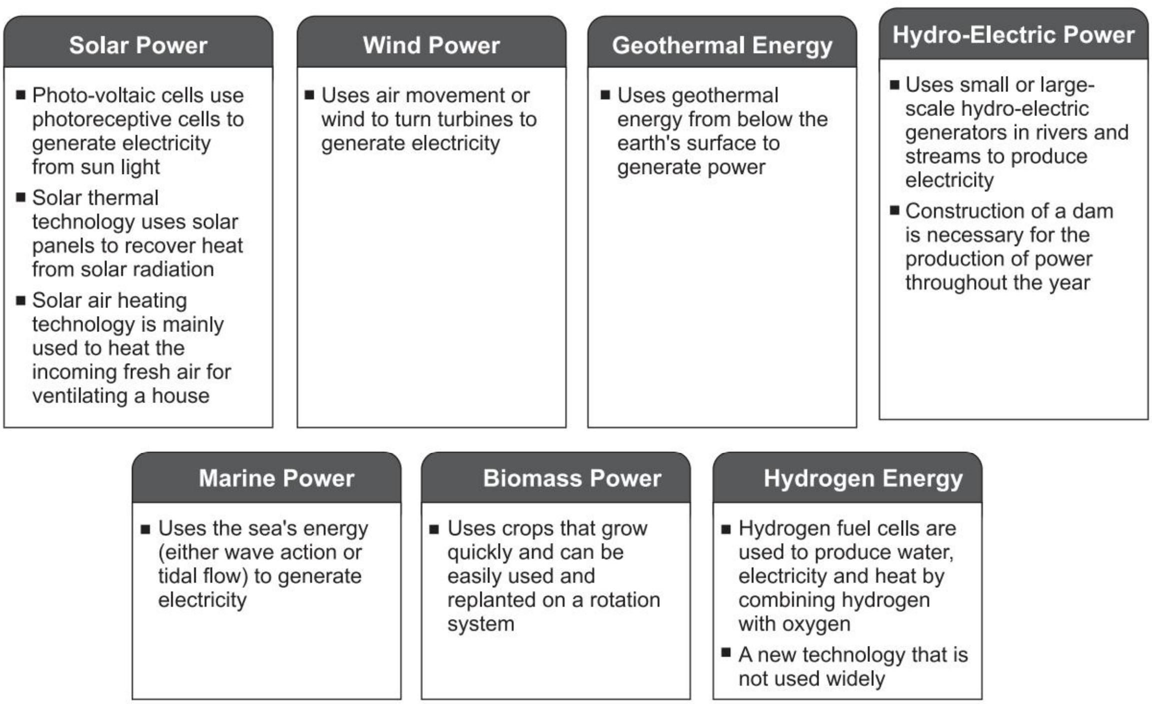


Fig. 2.11 *Major Sources of Energy*

In general, the three types of energy have very different characteristics. This means there is no 'ideal' energy source. The future will, most likely, to be a mix of sources with increasing emphasis on the renewables. The advantages and disadvantages of various energy types are listed in Table 2.2.

Table 2.2 *Advantages and Disadvantages of Various Energy Types*

Energy type	*Advantages*	*Disadvantages*
Renewable	■ Wide availability ■ Lower running cost ■ Decentralized power production ■ Low pollution ■ Available for the foreseeable future	■ Unreliable supply ■ Usually produced in small quantities ■ Often very difficult to store ■ Currently per unit cost of energy is more compared to other types
Non-renewable	■ Available in highly concentrated form ■ Easy to store ■ Reliable supply ■ Lower cost per unit of energy produced as the technology is matured	■ Highly polluting ■ Available only in a few places ■ High running cost ■ Limited supply and will one day get exhausted
Sustainable (Nuclear power)	■ Highly reliable ■ Produces large amounts of energy with very little CO_2 emissions ■ Uses small amount of raw material per unit energy production	■ Risk of radioactivity ■ High waste disposal costs ■ High capital investment and maintenance cost

It is unwise for any nation to rely only on one source of energy. Any shortage in energy availability or change in energy price would cause havoc with the national economy. This happened in the early 1970s when the major oil producing nations agreed to raise the price of oil by nearly 300%. The same trend was felt in 2004 when the price of crude oil touched 50US$ per barrel.

Nations attempt to reduce the risk of energy shortages or price raises by adopting different energy sources to give them more ***'energy security'***. The range of energy sources they choose is known as the ***energy mix***. The energy mix can be determined by many factors. These include:

- Economics—for example, the availability of cheap local resources or cheap imports from friendly allies
- Political and social considerations
- Environmental considerations

One country's preferred energy mix may be completely different from that of another. Even within the same country, the energy mix may change as time passes.

2.5.2 Energy Characteristics

Economic and military power depends on many factors, but significant among them is access to abundant cheap energy supplies to support industry and trade.

Many of the political groupings in the world are influenced by access to the raw materials for energy production.

2.5.3 Energy and the Environment

The production and consumption of energy is one of the biggest causes of environmental damage on earth. It has led to large amounts of destruction of natural landscapes and habitats through the process of fuel extraction, pollution of soil, water and air, poisoning of wildlife, and is generally believed to be the main cause of modern climate change.

Environmental impacts associated with energy can be split into two main areas:

1. Impacts that arise due to energy production (from fuel extraction to energy supplies), and
2. Impacts that arise due to energy use (including air pollution and climate change).

Impacts as a result of energy production vary according to the type of fuel, method of use or extraction, and the way in which it releases energy. For example, fossil fuels such as coal and oil are associated with high levels of gaseous emissions during the energy production process, notably carbon dioxide and other greenhouse gases that have been linked with climate change. This contrasts with nuclear fuel, which produces no greenhouse gas emissions, but uses uranium (which is highly toxic) and results in the production of radioactive wastes that are highly dangerous to all life forms and take a long time to decay.

Renewable energy sources generally have low impacts compared to non-renewable sources, and are likely to take over from traditional fuels for both environmental, economic and supply reasons in the future.

2.5.4 Fuel Cell

When electric current passes through water, its molecules split up at the electrodes forming hydrogen and oxygen. The reverse of this reaction is what happens in the fuel cell, i.e. when hydrogen and oxygen are combined from water, we could generate electricity. Even though in principle this looks simple, there are may practical difficulties to make this reaction work. William Grove (1839) is credited with the invention of this principle.

A fuel cell is an **electrochemical** energy conversion device that converts hydrogen and oxygen into water, producing electricity and heat in the process. It is very much like a battery that can be recharged while drawing power from it. Instead of recharging using electricity, a fuel cell uses hydrogen and oxygen. In principle, a fuel cell operates like a battery. Unlike a battery, a fuel cell does not run down or require recharging. It will produce energy in the form of electricity as long as fuel is supplied.

A fuel cell consists of two electrodes sandwiched around an electrolyte. Figure 2.12 shows the working of a fuel cell. Oxygen passes over one electrode and hydrogen over the other, generating electricity, water and heat.

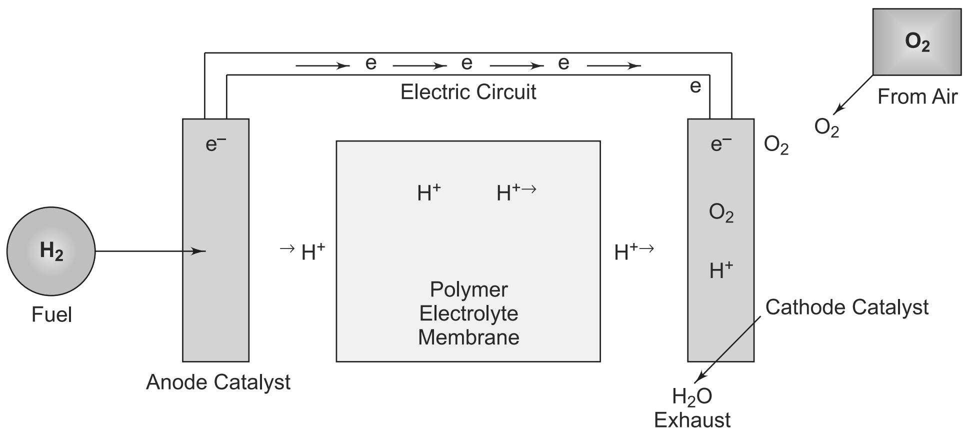


Fig. 2.12 *Fuel Cell*

Problems with Fuel Cells

A fuel cell uses oxygen and hydrogen to produce electricity. The oxygen required for a fuel cell comes from the air. Hydrogen has some limitations that make it impractical for use in most applications. Hydrogen is difficult and dangerous to store and distribute, so it would be much more convenient if fuel cells could use fuels that are more readily available. This problem is addressed by a fuel reformer. A fuel reformer turns hydrocarbon or alcohol fuels into hydrogen, which is then fed to the fuel cell. Unfortunately, fuel reformers are not perfect. They generate heat and produce other gases besides hydrogen.

Some of the more promising fuels are natural gas, propane and methanol. Methanol is a liquid fuel that has similar properties to gasoline. It is just as easy to transport and distribute, so methanol may be a likely candidate to power fuel-cell cars.

Future Fuel-Cell Technology

Direct fuel cells which extract hydrogen directly from a fuel such as methane without using a fuel reformer seem to be the future.

Major automotive makers are conducting research into fuel cell power plants, even as they begin introducing hybrid vehicles that use a combination of fossil fuel and electric motors.

Perhaps the most eagerly anticipated application is the use of fuel cells to supply electricity to homes and small businesses. For economic, environmental, and political reasons, the concept of "distributed generation" is becoming popular as the construction of new electric power plants and transmission lines is becoming difficult.

2.5.5 Saving Energy

By saving energy at home, while travelling and at work, we can reduce the impacts of energy production and use on the environment, and reduce the amounts of greenhouse gases that are released into the atmosphere.

Energy-saving Tips

Energy can be saved at home in several easy ways, including the following:

- Turning the lights off whenever you leave a room,
- Using energy saving light bulbs in rooms,
- Turning the heating down or off in rooms that aren't being used regularly,
- Ensuring that window and door seals are in good condition,
- Making sure cavity walls and loft spaces are well insulated,
- Only filling the kettle with as much water as you need to use,
- Using sun light to dry clothes in the summer rather than a mechanical cloth drier,
- Choosing low energy rating appliances for cooking, washing and refrigerating, and
- Making sure that hot water boilers and pipes are well insulated.

2.6 LAND RESOURCES

Land Resources

Natural resources, in the context of "land", are taken to be those components of land units that are of direct economic use for human population living in the area, or expected to move into the area such as the following:

- Near-surface climatic conditions;
- Soil and terrain conditions;
- Freshwater conditions; and
- Vegetation and animal conditions.

Environmental Resources

Environmental resources are taken to be those components of the land that have an intrinsic value of their own, or are of value for the longer-term sustainability of the use of the land by human populations, either regional or global. They include the following:

- Biodiversity of plant and animal populations,
- Scenic, educational or research value of landscapes,
- Protective value of vegetation in relation to soil and water resources,
- The functions of the vegetation as a regulator of the local and regional climate and of the composition of the atmosphere, and
- Water and soil conditions as regulators of nutrient cycles (C, N, P, K, S), as influencing human health and as a long-term buffer against extreme weather events.
- Environmental resources are to a large degree "intangible" in strictly economic terms.

2.6.1 Land Degradation

Land degradation, a decline in land quality caused by human activities, has been a major global issue during the 20th century and will remain high on the international agenda in the 21st century.

Mechanisms that initiate land degradation include physical, chemical, and biological processes.

Physical processes Decline in soil structure leading to crusting, compaction, erosion, desertification, anaerobism, environmental pollution, and unsustainable use of natural resources.

Chemical processes Acidification, leaching, decrease in cation retention capacity, and fertility depletion.

Biological processes Reduction in total and biomass carbon, and decline in land biodiversity. Soil structure is an important property that affects all three degradative processes.

Thus, land degradation is a biophysical process driven by socio-economic and political causes. Factors of land degradation are the biophysical processes and attributes that determine the kind of degradative processes, e.g. erosion, leaching, etc. These include land quality as affected by its intrinsic properties of climate, terrain and landscape position, and biodiversity, especially soil biodiversity. The agents that determine the rate of degradation are the following:

- Biophysical (land use and land management, including deforestation and tillage methods),
- Socio-economic (e.g. income and human health),
- Political (e.g. incentives, political stability). Land degradation is as much a socio-economic problem as it is a biophysical problem. Land degradation and economic growth or lack of it (poverty) are intractably linked.

2.6.2 Soil Erosion

Soil erosion is a natural process. It becomes a problem when human activity causes it to occur much faster than under natural conditions.

Causes of Soil Erosion

- Wind and water are the main agents of soil erosion. The amount of soil they can carry away is influenced by two related factors:
  - Speed — the faster wind or water moves, the more soil it can erode;
  - Plant cover—plants protect the soil and in their absence wind and water can do much more damage.

Preventing Soil Erosion

Preventing soil erosion requires political, economic and technical changes. Political and economic changes need to address the possibility of incentives to encourage farmers to manage their land sustainably. Aspects of technical changes in agriculture that could substantially contribute to the prevention of soil erosion are the following:

- Use of contour ploughing and wind breaks;
- Leaving unploughed grass strips between ploughed land;
- Making sure that there are always plants growing on the soil, and that the soil is rich in humus (decaying plant and animal remains). This organic matter is the "glue" that binds the soil particles together and plays an important part in the prevention of erosion;
- Avoiding overgrazing and the over-use of crop lands;
- Allowing indigenous plants to grow along the river banks instead of ploughing and planting crops right up to the water's edge;

- Encouraging biological diversity by planting several different types of plants together; and
- Conservation of wetlands.

2.6.3 Desertification

Desertification is a form of land degradation occurring particularly, but not exclusively, in semi-arid areas.

While there is a clear distinction between 'soil' and 'land' (the term land refers to an ecosystem comprising land, landscape, terrain, vegetation, water, climate), there is no clear distinction between the terms 'land degradation' and 'desertification'.

Desertification refers to land degradation in arid, semi-arid, and sub-humid areas due to anthropogenic activities.

Causes of Desertification

Natural causes of desertification:

- Decreased rainfall
- Increased temperature
- Lowering of water table
- Soil erosion
- Soil compaction

Human-aided desertification:

- Overgrazing
- Destruction of forest belts (Deforestation)
- Salinization
- Exhaustion of the soil by intensive cultivation without restoration of fertility

2.6.4 Landslides

Geologists use a variety of classification schemes to describe the causes of landslides. Because of wide variety of causes, no single scheme has yet been developed that addresses or describes all types of landslides. Even the terms assigned to types of landslides are undergoing standardization among geological and scientific international agencies. The major causes of landslides can be clasified into two groups, namely external and internal as illustrated in Fig. 2.13.

All the major causes of landslides point towards some or other form of human activity and hence it is essential to be discreet about developmental activities in areas prone to landslides.

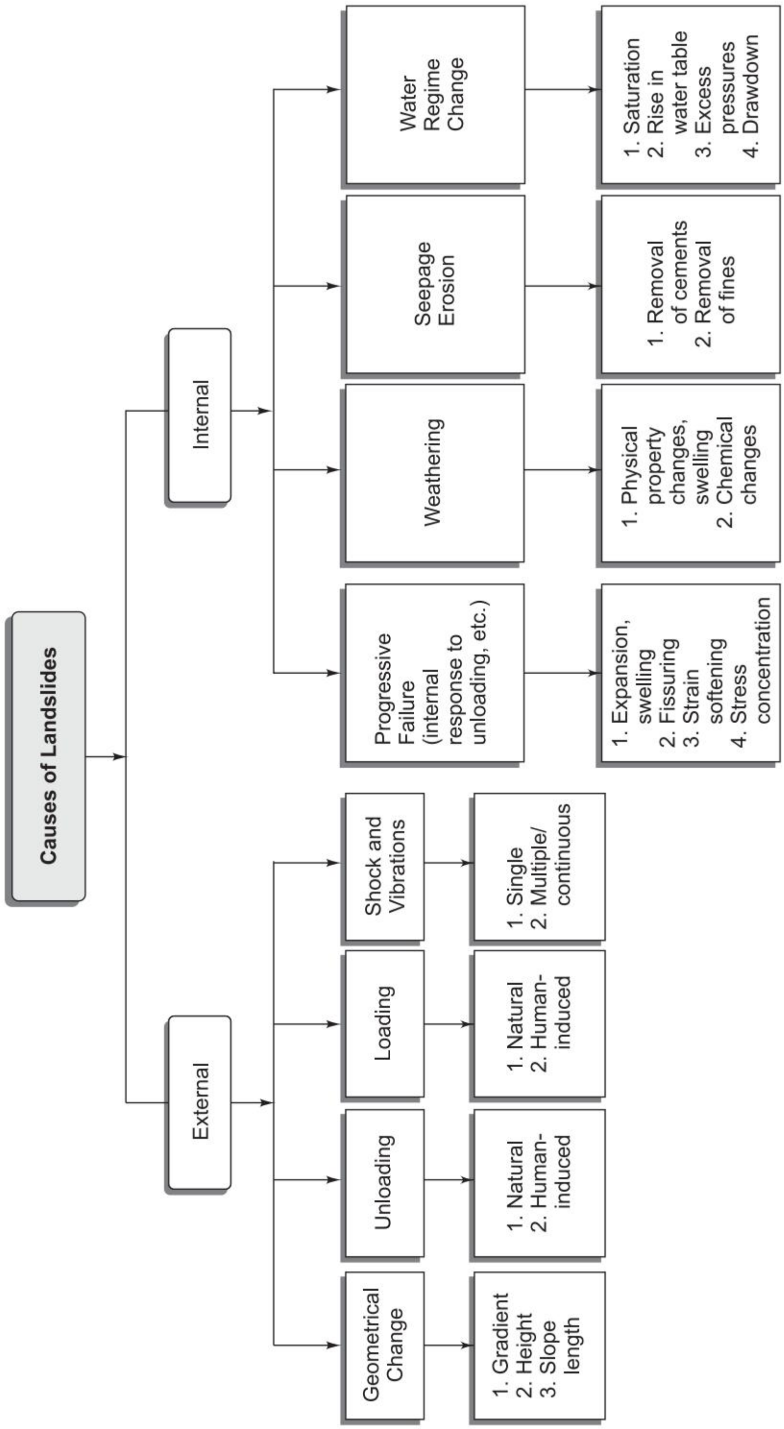


Fig. 2.13 *Causes of Landslides*

REVIEW QUESTIONS

Objective-Type Questions

1. As per the FAO definition the minimum percentage of depletion of tree crown cover, that can be considered as deforestation is

(a) 50% (b) 60%

(c) 70% (d) 90%

2. Which of the following statements about the forest is not correct?

(a) Reduces soil erosion

(b) Provides recreational opportunities

(c) Provides a source of economic development

(d) None of the above

3. Which of the following type of timber extraction is least damaging to the environment?

(a) Clear felling

(b) Reduced impact logging

(c) Mechanized logging

(d) Hand logging

4. Which of the following is not true about deforestation?

(a) Population explosion is one of the reasons for deforestation

(b) Clearing of forest for agriculture causes deforestation

(c) Deforestation is taking place only in developing countries

(d) Cash crop economy of the third world is a cause of deforestation

5. "The value of a forest is often higher when it is left standing than it could be worth when it is harvested." Which of the following factors is most supportive of the above statement?

(a) Increase in timber value as time passes

(b) Increase in wildlife

(c) Increase in ecotourism

(d) Increase in forest produce

6. The removal of carbon dioxide from the earth's atmosphere and the provision of long-term storage of carbon in the terrestrial biosphere is known as
(a) carbon sequestration
(b) carbon dating
(c) carbon fixing
(d) photosynthesis

7. How does dams affect deforestation?
(a) Open up previously inaccessible forest to public
(b) Submerges forest
(c) Damages downstream ecosystems
(d) All of the above

8. Which of the following is not a viable protection against deforestation?
(a) Reduce the consumption of forest and related products.
(b) Boycott products of companies involved in deforestation.
(c) Privatization of forest land.
(d) Environmental education.

9. India has the world's largest share of which of the following?
(a) Manganese (b) Mica
(c) Copper (d) Diamond

10. The major purpose of most of the dams around the world is
(a) power generation
(b) irrigation
(c) drinking water supply
(d) flood control

11. Which of the following could be the most important socio-economic impact of dams?
(a) Loss of biodiversity
(b) Poorly managed involuntary displacement and loss of livelihood
(c) Loss of forests and wildlife habitat
(d) Waterlogging

12. Which of the following is not an ideal solution for tackling the water crisis?
(a) Drilling large number of deep bore wells

(b) Population growth control
(c) Water conservation in irrigation
(d) Water pollution control

13. What is the major characteristic of drought, differentiating it from other natural calamities?
(a) Drought could cause life and property loss
(b) Drought has both natural and social implications
(c) Drought could recur in the same place
(d) Without a well-defined start nor end, drought is a slow process

14. Which of the following measures is not a solution for improving the acceptability of dam projects?
(a) Avoid and minimize ecosystem impacts.
(b) Ensure that displaced and project-affected peoples' livelihoods are improved.
(c) Conduct regular monitoring and periodic review.
(d) Construct a single large dam instead of a number of small dams.

15. Which of the following is not a necessary condition for ensuring food security?
(a) Availability of food
(b) Access to food
(c) Self-sufficiency in the production of food within a country
(d) Must fulfil nutritional requirements

16. Which of the following is an adverse effect of modern agriculture?
(a) Water scarcity
(b) Water pollution
(c) Waterlogging
(d) All of the above

17. Out of the following nutrients in fertilizer, which one causes minimum water pollution?
(a) Nitrogen
(b) Phosphorus
(c) Potassium
(d) Organic matter

18. Select the least harmful class of compounds from the following:
(a) Chlorinated hydrocarbons
(b) Organophosphates

(c) Carbamates
(d) Pyrethroids

19. Select the most environmental-friendly method of insect control from the following:
(a) Application of organophosphates
(b) Application of Chlorinated hydrocarbons
(c) Application of pyrethroids
(d) Crop rotation and intercropping

20. Which of the following is the most environmental-friendly agriculture?
(a) Use of chemical fertilizers and insecticides
(b) Use of insecticides and organic fertilizers
(c) Use of organic fertilizers and alternate methods for insect control
(d) Use of chemical fertilizers and alternate methods for insect control

21. Identify the nonrenewable source of energy from the following:
(a) Coal (b) Fuel cells
(c) Wind power (d) Wave power

22. Which of the following is a disadvantage of most of the renewable energy sources?
(a) Highly polluting
(b) High waste disposal cost
(c) Unreliable supply
(d) High running cost

23. What is the function of a fuel reformer in a fuel cell?
(a) Enabling the fuel cell to use a hydrocarbon instead of hydrogen
(b) Control of emissions from fuel cell
(c) Cooling of fuel cell
(d) Enabling the fuel cell to use water as a fuel

24. Which of the following forms of land degradation is more prevalent in India?
(a) Desertification
(b) Soil erosion
(c) Landslide
(d) Soil subsidence

Short-Answer Questions

1. Define the term *deforestation*.
2. Differentiate between deforestation and forest degradation.
3. Cite examples for aesthetic, recreational, economic, historical, cultural and religious values of forests around your place.
4. List the effects of deforestation.
5. List the possible social impacts of mining on local communities.
6. Write a short note on the mineral resources of India.
7. Identify the core causes of current water crisis in the world.
8. Define *meteorological drought*.
9. Define *food security*.
10. Enumerate the desired qualities of an ideal pesticide.
11. Define organic farming.
12. List the advantages of organic agriculture over the conventional one.
13. What are the major energy sources of planet earth?
14. Differentiate between renewable, non-renewable and sustainable sources of energy with examples.
15. What is geothermal energy?
16. Enumerate the methods of prevention of soil erosion.
17. Define the term *desertification*. What are the international efforts to prevent the same?
18. Explain the causes of landslides.

Descriptive Questions

1. What are the key benefits of intact forests?
2. What are the ecological benefits of forests?
3. Explain the common causes of deforestation around the world.

4. Explain the environmental impacts of deforestation.
5. What are the actions that could serve as solutions to the problem of deforestation?
6. Explain the impacts of timber extraction/logging on forests.
7. Classify the methods of logging and compare its impact severity on deforestation.
8. "Environmental damages caused by mining last long after the mine has closed." Explain.
9. What are the purposes for which dams are built traditionally?
10. Explain the benefits of dams.
11. List the major arguments cited against the construction of dams.
12. Discuss the ethical dilemma with dams in the Indian context.
13. Hydroelectric power is generally considered as clean energy. However, what are the problems related with dams make you doubtful about it?
14. Debate on the topic "Dams a boon or bane to human civilization".
15. Elaborate on the anomalies in the distribution and utilization of water resources around the world.
16. Define 'Drought' and explain how it is interpreted based on meteorological, agricultural, hydrological and socio-economic effects.
17. "Water could be the source of the world's next big conflicts." Explain.
18. Discuss the contrasting views of the experts on the food security of the world in the near future.
19. Explain the adverse environmental impacts of modern agriculture.
20. List the environmental problems associated with the following:
    (a) Chemical fertilizers (b) Pesticides
21. Explain the various pros and cons of modern-day pesticides.
22. Discuss the alternative methods of insect control avoiding the use of pesticide.
23. Compare the various types of energy with respect to its suitability for Indian conditions.
24. Compare and contrast nuclear power with solar power from the environmental point of view.

25. With a neat sketch, explain the working of a fuel cell.

26. Explain the possible contributions of individuals towards energy conservation.

27. Discuss the various types of land degradation with its causes and solutions.

Answers to Objective-Type Questions

1. (d)	2. (d)	3. (b)	4. (c)	5. (c)	6. (a)	7. (d)
8. (c)	9. (b)	10. (b)	11. (b)	12 (a)	13. (d)	14. (d)
15. (c)	16. (d)	17. (c)	18. (d)	19. (d)	20. (c)	21. (a)
22. (c)	23. (a)	24. (b)				

3 ECOLOGY

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

Barry Commoner

Learning Outcomes

On successful completion of this chapter, students will be able to:

- Explain the concept of ecosystem and compare it with anthroposystem.
- Illustrate the terms Food Chain, Food Web and Ecological Pyramid.
- Sketch and explain the major biogeochemical cycles.
- Demonstrate the structure and functions associated with forest, grassland and aquatic ecosystems.

3.1 ECOSYSTEM

Ecology is the study of the relationship between organisms and their environment. *An ecosystem is a biotic assemblage of plants, animals, and microbes, taken together with their physico-chemical environment.* In an ecosystem the biological cycling of materials is maintained by three groups, viz., producers, consumers, and decomposers/recyclers (Fig. 3.1).

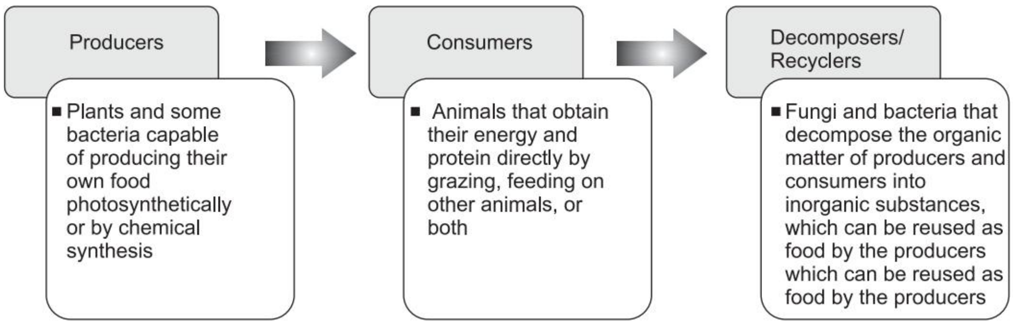


Fig. 3.1 *Biological Cycling of Materials in an Ecosystem*

Functionally, human activities that disturb the natural environment can also be divided into three similar components (Fig. 3.2). An ecosystem relies on its decomposers for a complete recycling of its elements, while the anthroposystem lacks such efficient decomposers and recyclers. As such, manufactured materials that are no longer needed and waste by-products of industrial activities are largely disposed into the physical environment. Figures 3.3 and 3.4 illustrate the movement of chemicals and materials through natural ecosystem and anthroposystem.

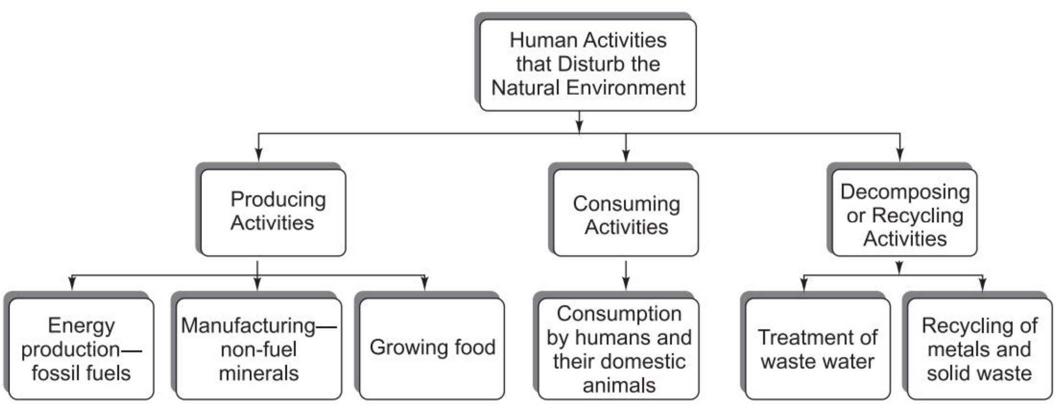


Fig. 3.2 *Human Activities that Disturb the Natural Environment*

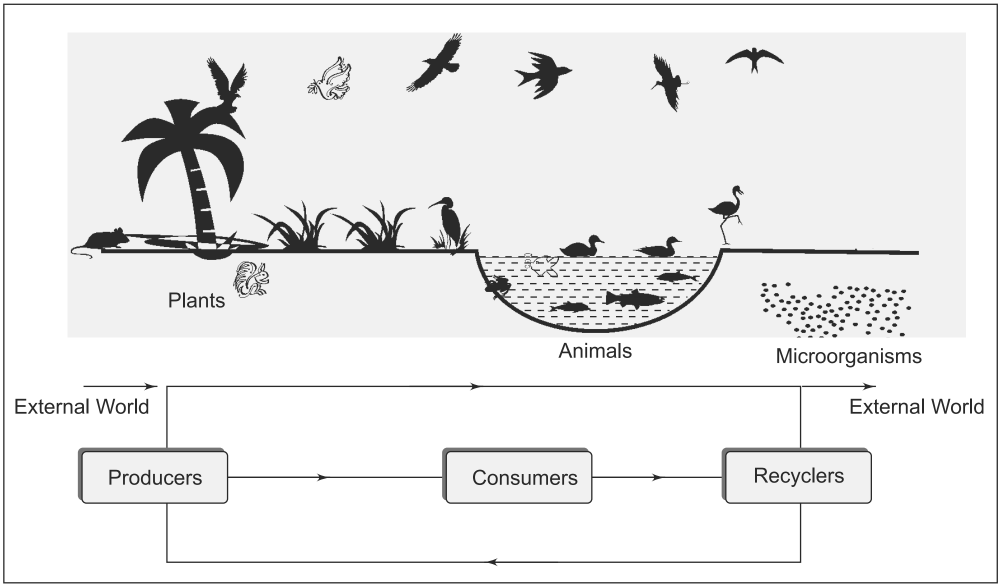


Fig. 3.3 *Movement of Chemicals and Materials through a Natural Ecosystem*

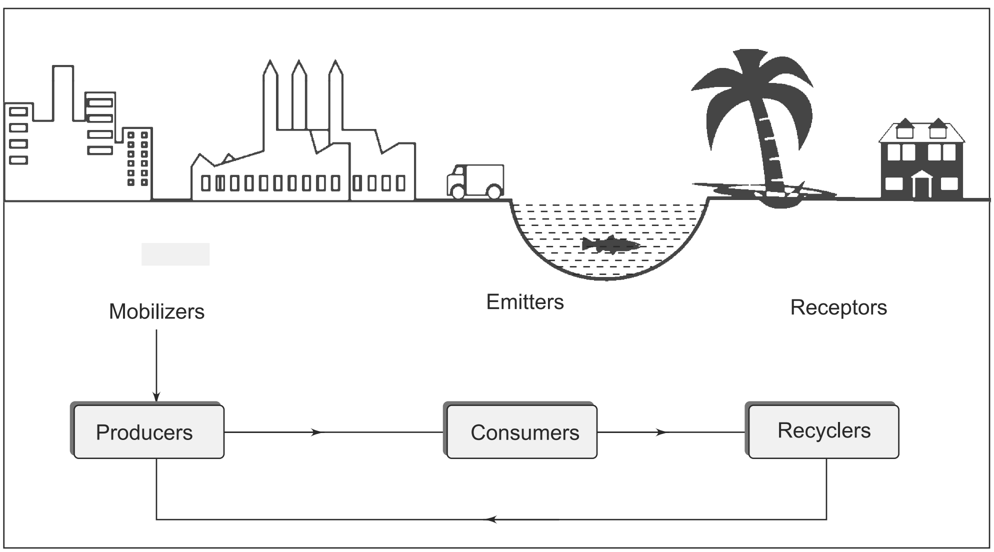


Fig. 3.4 *Movement of Chemical Materials through a System Resulting from Human Activities (Anthroposystem)*

3.2 ECOSYSTEM–ANTHROPOSYSTEM COMPARISON

Table 3.1 gives a comparison of ecosystem and anthroposystem.

Table 3.1 *Comparison of Ecosystem and Anthroposystem*

Ecosystem	*Anthroposystem*
Most of the materials are transferred from the producers to the recyclers, and only a small fraction is passed through the consumers to the recyclers.	The flow from the producers to the recyclers is small or even non-existent since it would be pointless to produce/ mobilize materials and recycle them immediately without a consumer in the loop.
The decomposers return most of the materials to the producers for reuse.	Much of the mobilized materials are transferred to the rest of the material environment, to the producer and to the consumer.
Sustained development (ecosystem) is facilitated by a close physical proximity and functional matching between the producers and consumers.	There is usually a significant physical displacement between the producer and the consumer.

3.3 BIOME AND ECOSYSTEM

A biome is a large area with similar flora, fauna, and microorganisms and is generally designated by the dominant vegetation. The following are the major biomes of the world.

- Mountains (high elevation)
- Tundra
- Temperate forest
- Marine/Island
- Desert
- Tropical dry forest
- Cold climate forest
- Grassland
- Savannah
- Tropical rainforest

An ecosystem is much smaller than a biome. Conversely, a biome can be defined as various similar ecosystems throughout the world grouped together. An ecosystem can be as large as the Sahara Desert, or as small as a puddle.

3.4 ENERGY FLOW THROUGH AN ECOSYSTEM

Figure 3.5 shows how both energy and inorganic nutrients flow through the ecosystem. Energy "flows" through the ecosystem in the form of carbon-carbon bonds. When respiration occurs, the carbon-carbon bonds are broken and the carbon is combined with oxygen to form carbon dioxide. This process releases the energy, which is either used by the organism (to move its muscles, digest food, excrete wastes, think, etc.) or the energy may be lost as heat. The dotted arrows represent the movement of this energy. All energy comes from the sun, and the ultimate fate of all energy in ecosystems is to be lost as heat. Energy does not recycle.

The other components shown in the diagram are the inorganic nutrients. They are inorganic because they do not contain carbon-carbon bonds. These inorganic nutrients include the phosphorous in our teeth, bones, and cellular membranes; the nitrogen in our amino acids (the building blocks of protein); and the iron in our blood. The movement of the inorganic nutrients is represented by the open arrows. Note that the autotrophs obtain these inorganic nutrients from the inorganic nutrient pool, which is usually the soil or water surrounding the plants or algae. These inorganic nutrients are passed from organism to organism as one organism is consumed by another. Ultimately, all organisms die and become detritus, food for the decomposers. At this stage, the rest of the energy is extracted (and lost as heat) and the inorganic nutrients are returned to the soil or water to be taken up again. The inorganic nutrients are recycled, but the energy is not recycled.

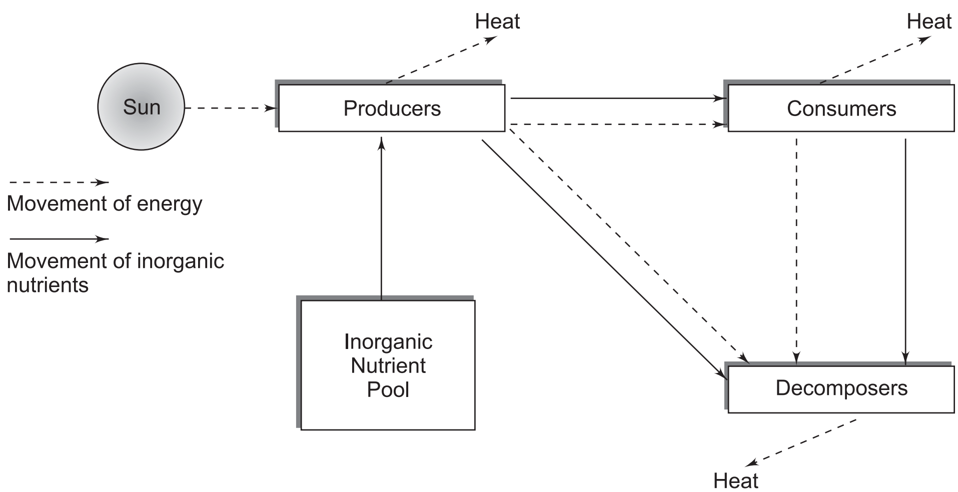


Fig. 3.5 *Energy and Nutrient Flow through an Ecosystem*

3.5 ECOLOGICAL SUCCESSION

Ecological succession is the gradual process by which ecosystems change and develop over a period of time. 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 replaced by a new set of species which are better adapted to the new conditions.

Ecological succession may also occur when the conditions of an environment suddenly and drastically change. A forest fire, wind storm, and human activities like agriculture etc. greatly alter the conditions of an environment. The following are the three proposed hypotheses pertaining to the mechanism of replacement.

Facilitation Hypothesis

This hypothesis states that the invasion of later species depends on the conditions created by earlier colonists. Earlier species modify the environment so as to increase the competitive ability of species which are then able to displace them. Succession thus proceeds because of the effects of species on their environment.

Tolerance Hypothesis

This suggests that later successional species tolerate lower levels of resources than earlier occupants and can invade and replace them by reducing resource levels below those tolerated by earlier occupants. Succession proceeds despite the resistance of earlier colonists.

Inhibition Hypothesis

This hypothesis states that all species resist invasion of competitors and are displaced only by death or by damage from factors other than competition. Succession proceeds towards dominance by longer-lived species.

3.6 FOOD CHAINS AND WEBS

A food chain is the path of food from a given final consumer back to a producer. For instance, a typical food chain in a field ecosystem is

grass → grasshopper → mouse → snake → hawk

The real world is more complicated than a simple food chain. While many organisms specialize in their diets (e.g. Anteaters), other organisms do not. Hawks don't limit their diets to snakes, snakes eat things other than mice, mice eat grass as well as grasshoppers. A more realistic representation of who eats whom is called a food web. An example of a food web is shown in Fig. 3.6.

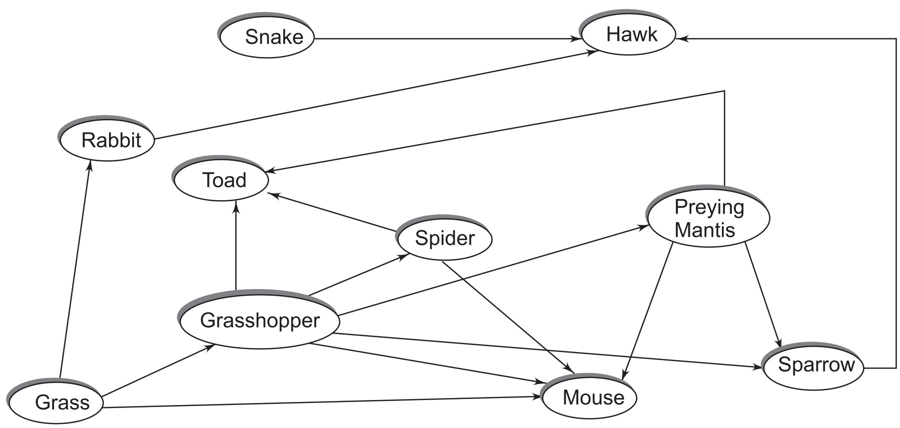


Fig. 3.6 *Food Web*

A food web consists of interlocking food chains, and the only way to untangle the chains is to trace back along a given food chain to its source.

3.7 ECOLOGICAL PYRAMIDS

In a food chain the number of individuals decreases at each trophic level (a trophic level refers to an organism's position in the food chain) with huge number of tiny individuals at the base and a few large individuals at the top. This formation is known as ecological pyramid. Figure 3.7 illustrates the above concept.

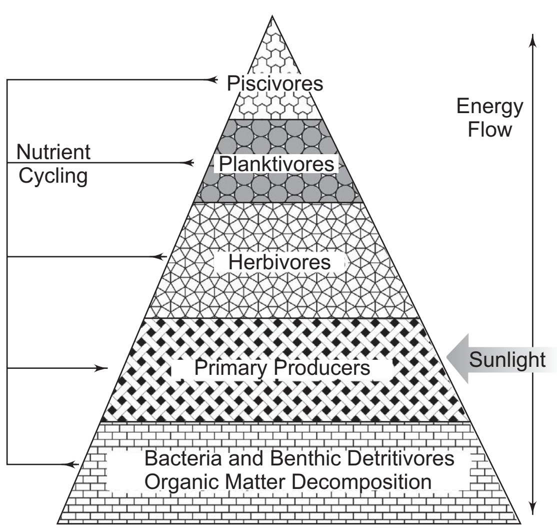


Fig. 3.7 *The Ecological Pyramid in a Lake*

It is a general principle that the farther a trophic level is from its source or producer, the less biomass it will contain (biomass here would refer to the combined weight of all the organisms in the trophic level). This reduction in biomass occurs due to several reasons such as the following:

- Not everything in the lower levels gets eaten
- Not everything that is eaten is digested
- Energy is always being lost as heat

3.8 BIOLOGICAL MAGNIFICATION OR BIOMAGNIFICATION

Biological magnification is the tendency of pollutants to become concentrated in successive trophic levels (Fig. 3.8).

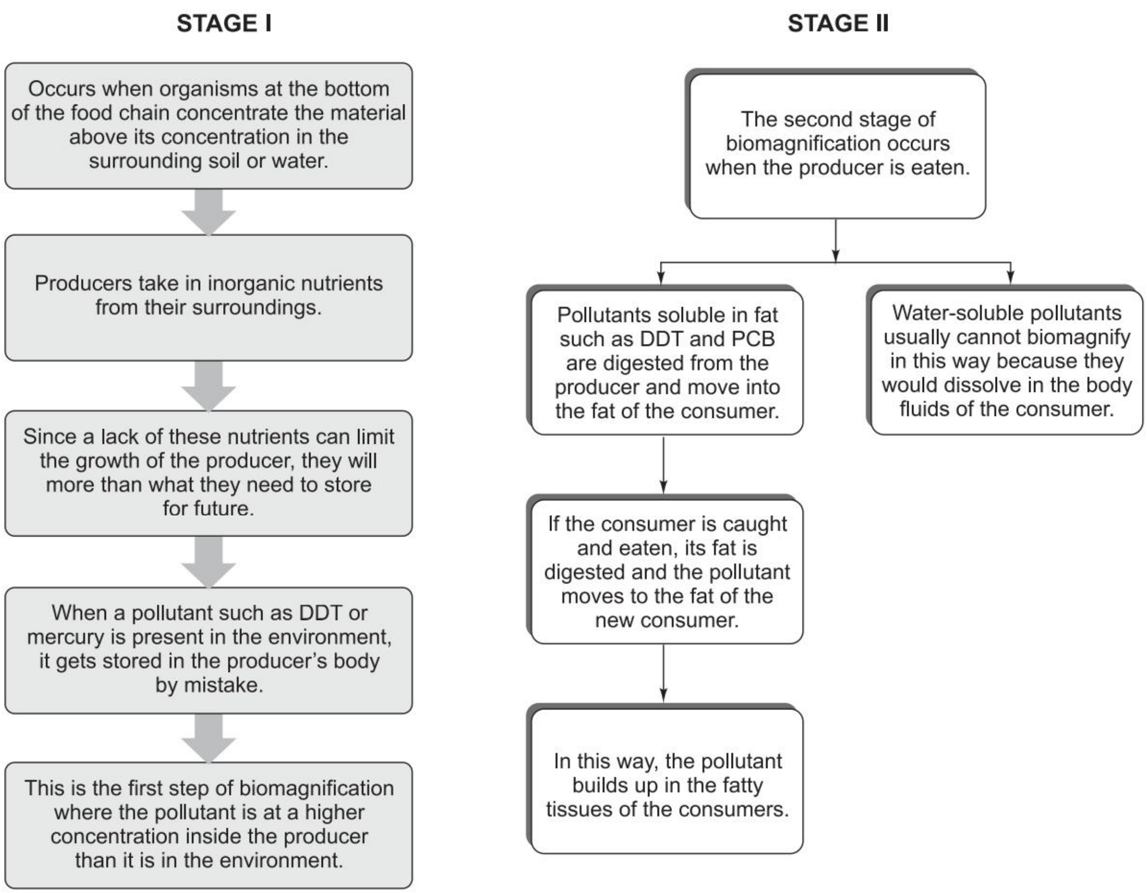


Fig. 3.8 *Occurrence of Biomagnification*

3.9 HUMAN VERSUS NATURAL FOOD CHAINS

Agriculture is manipulating the environment to favour plant species that we can eat. Agricultural ecosystems have several problems. First, we create monocultures, or fields with only one crop. This is simplest for planting, weeding, and harvesting, but it also packs many similar plants into a small area, creating a situation ideal for diseases and insect pests. In natural ecosystems, plants of one species are often scattered. Insects, which often specialize on feeding on a particular plant species, have a hard time finding the scattered plants. Another problem with human agriculture is that we rely on relatively a few plants for food.

A final problem associated with agroecosystems is the problem of inorganic nutrient recycling. In a natural ecosystem, when a plant dies, it fals to the ground and rots, and its inorganic nutrients are returned to the soil from which they were taken.

3.10 BIOGEOCHEMICAL CYCLES

We have already seen that while energy does not recycle through an ecosystem, chemicals do. Since the inorganic chemicals get recycled through both biological and geological worlds, we call the overall cycles biogeochemical cycles.

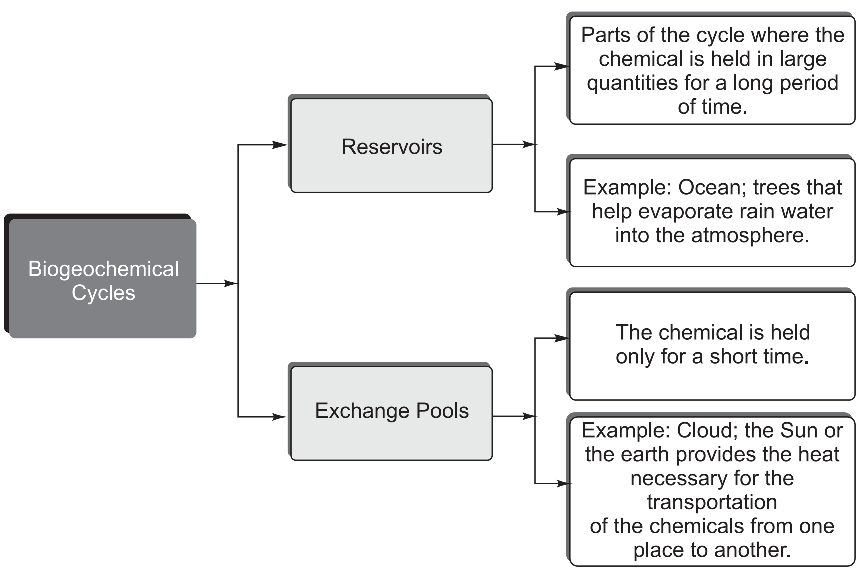


Fig. 3.9 *Reservoirs and Exchange Pools in a Biogeochemical Cycle*

3.11 WATER CYCLE (HYDROLOGIC CYCLE)

Precipitation and evaporation continue for ever, and thereby a balance is maintained between the two. This process is known as hydrologic cycle and is shown in Fig. 3.10.

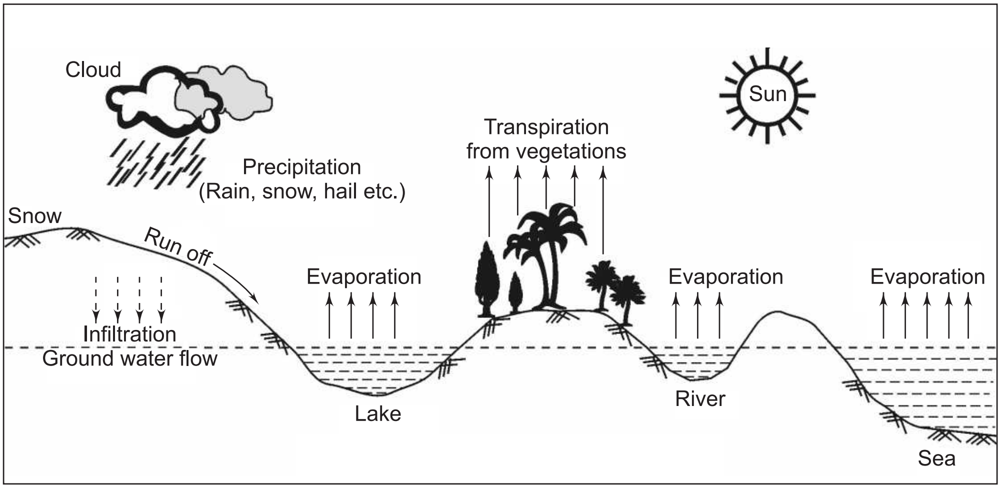


Fig. 3.10 *The Hydrologic Cycle*

3.12 CARBON CYCLE

Carbon is the major chemical constituent of most organic matter, from fossil fuels to the complex molecules (DNA and RNA) that control genetic reproduction in organisms. Yet by weight, carbon is not one of the most abundant elements within the Earth's crust.

Carbon is the second most abundant substance in living organisms next to water. Humans obtain their carbon in the carbon cycle by eating plants or eating animals that eat plants and thus all carbon in biological systems ultimately comes from plants (autotrophs). The chief reservoirs for carbon dioxide are in the oceans and in rock. Carbon dioxide dissolves readily in water. Once there, it may precipitate as a solid rock known as calcium carbonate (limestone). Corals and algae encourage this reaction and build up limestone reefs in the process.

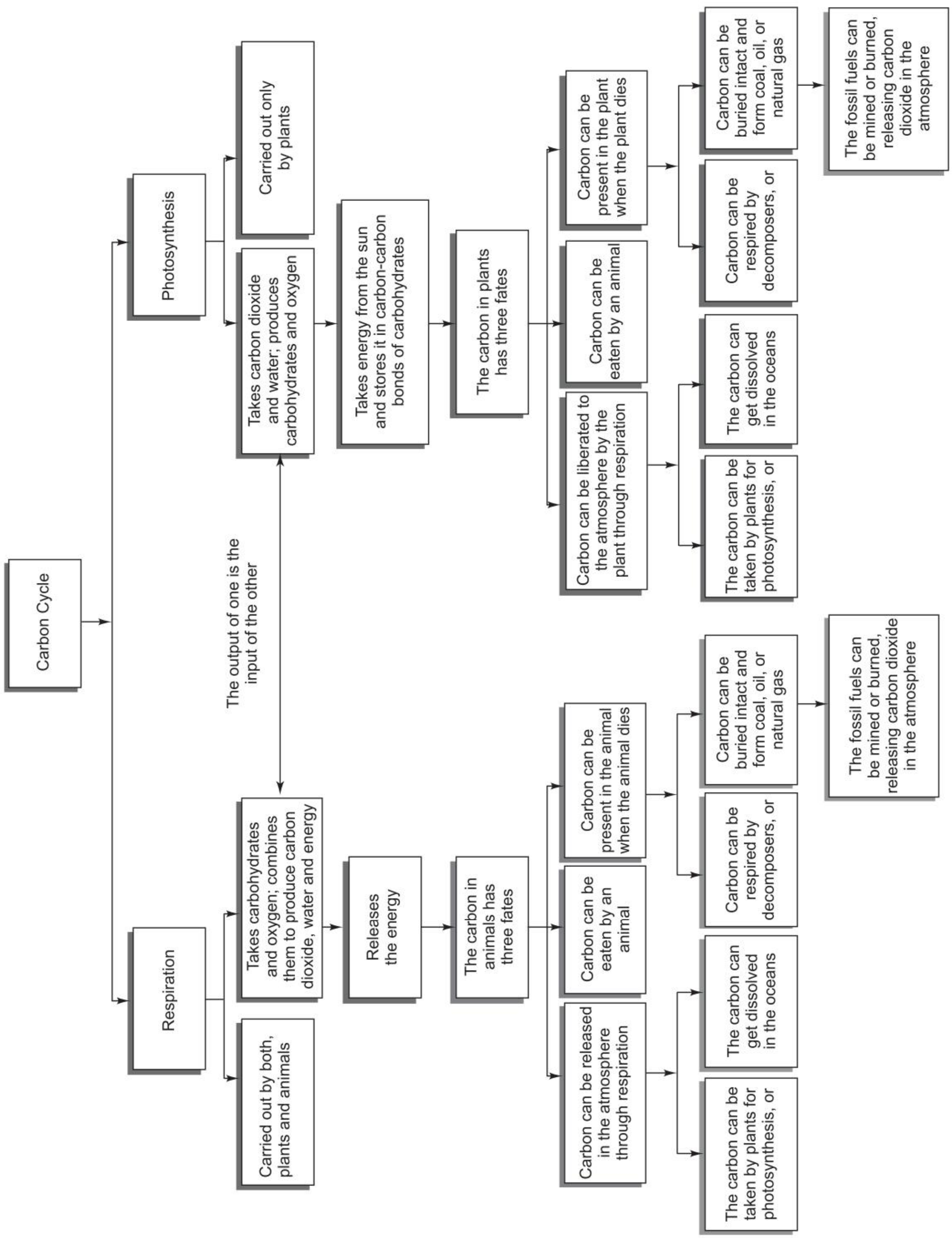


Fig. 3.11 *Flow of Carbon through Animals and Plants*

The carbon in limestone or other sediments can only be released to the atmosphere when they are subducted and brought to volcanoes, or when they are pushed to the surface and slowly weathered away. Humans have a great impact on the carbon cycle because when we burn fossil fuels we release excess carbon dioxide into the atmosphere. This means that more carbon dioxide goes into the oceans as well as to the atmosphere. The latter condition causes global warming, because the carbon dioxide in the atmosphere allows more energy to reach the Earth from the Sun than it allows to escape from the Earth into space.

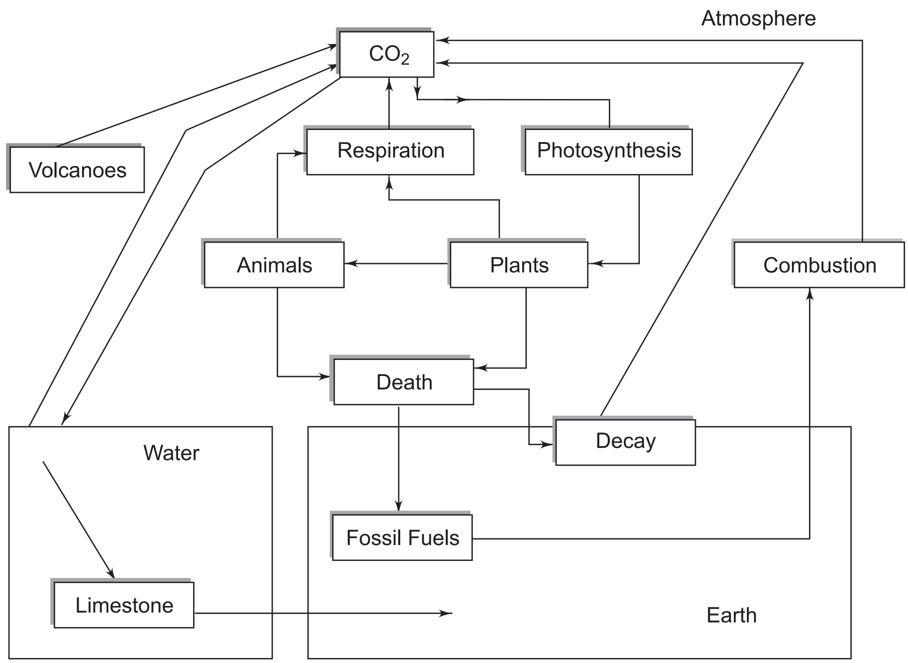


Fig. 3.12 *Carbon Cycle*

3.13 OXYGEN CYCLE

The carbon cycle explained earlier covers the oxygen cycle also because these atoms are often combined. Oxygen is present in carbon dioxide, carbohydrates and water. Oxygen is released to the atmosphere by autotrophs during photosynthesis and taken up by both autotrophs and heterotrophs during respiration. All the oxygen in the atmosphere is biogenic, i.e. it was released from water through photosynthesis by autotrophs. It took about two billion years for autotrophs (mostly cyanobacteria) to raise the oxygen content of the atmosphere to the current 21%. This opened the door for complex organisms such as multicellular animals, which need a lot of oxygen. This in turn enabled the evolution of complex organisms such as animals and human beings.

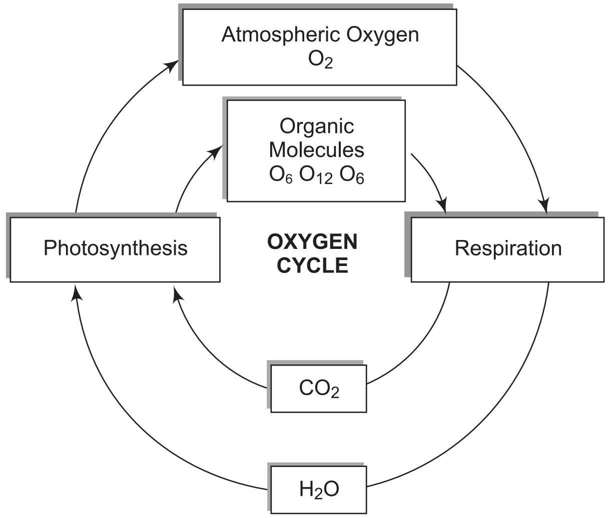


Fig. 3.13 *Oxygen Cycle*

3.14 NITROGEN CYCLE

The nitrogen cycle represents one of the most important nutrient cycles found in terrestrial ecosystems. Nitrogen is used by living organisms to produce a number of complex organic molecules like amino acids, proteins, and nucleic acids. The largest reservoir of nitrogen is the atmosphere where it exists as a gas (mainly N_2).

All of these fix nitrogen, either in the form of nitrate or in the form of ammonia (nitrogen with 3 hydrogens attached). Most plants can take up nitrate and convert it to amino acids. Animals acquire all of their amino acids when they eat plants (or other animals). When plants or animals die (or release waste), the nitrogen is returned to the soil. The usual form of nitrogen returned to the soil in animal wastes or in the output of the decomposers, is ammonia. Ammonia is rather toxic, but, fortunately, there are nitrite bacteria in the soil and in the water which take up ammonia and convert it to nitrite, which is nitrogen with two oxygens. Nitrite is also somewhat toxic, but another type of bacteria, the nitrate bacteria, take nitrite and convert it to nitrate, which can be taken up by plants to continue the cycle. We now have a cycle set up in the soil (or water). But what returns nitrogen to the air? It turns out that there are denitrifying bacteria which take the nitrate and combine the nitrogen back into nitrogen gas.

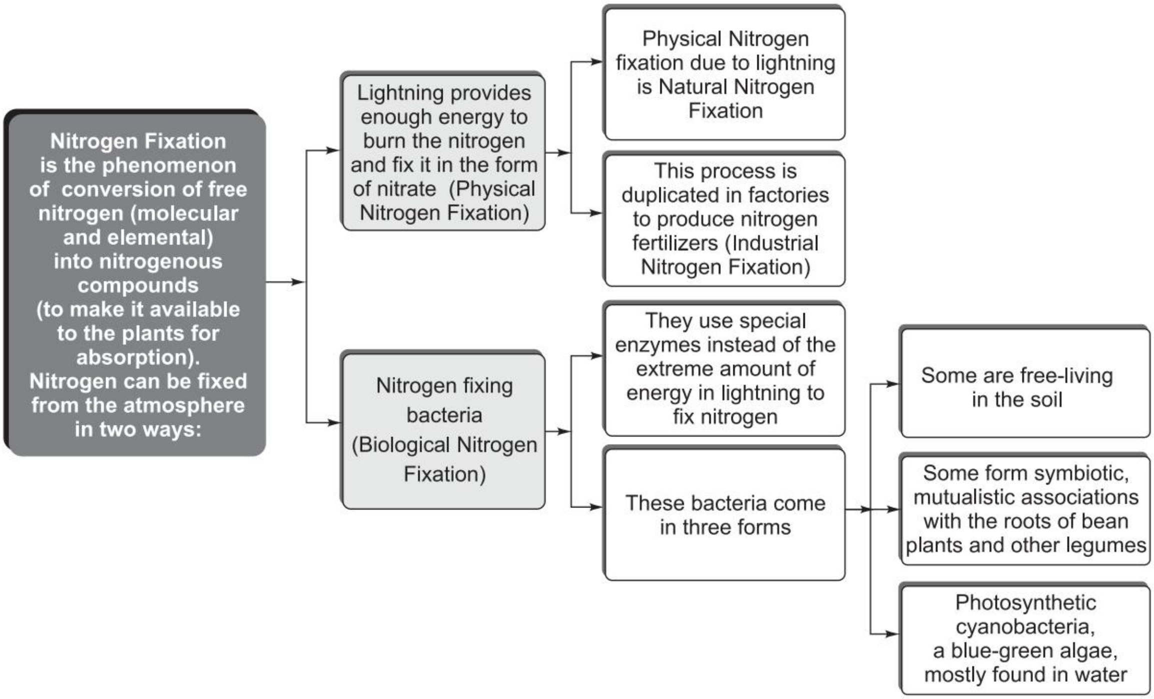


Fig. 3.14 *Physical and Biological Nitrogen Fixation*

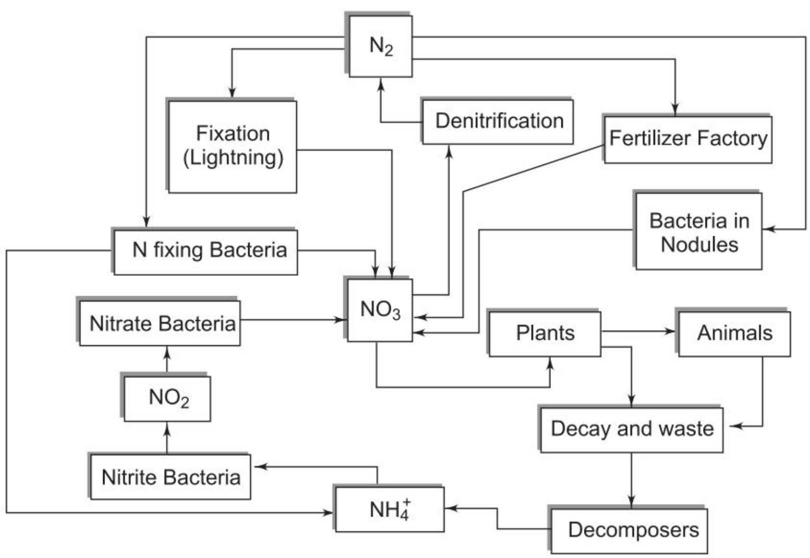


Fig. 3.15 *Nitrogen Cycle*

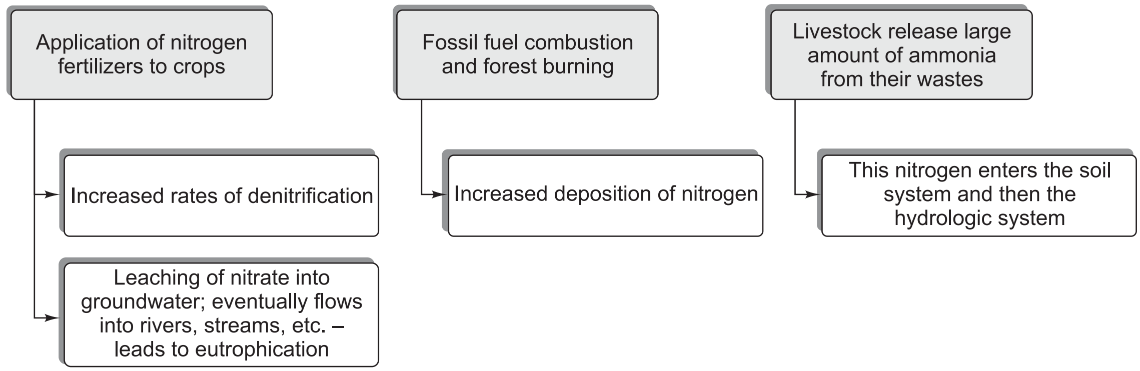


Fig. 3.16 *Human Activities that Alter the Nitrogen Cycle*

3.15 PHOSPHORUS CYCLE

In nature, phosphorus in the form of phosphate is present in rocks. When rock with phosphate is exposed to water (especially water with a little acid in it), the rock is weathered out and goes into solution. Autotrophs take this phosphorus up and use it in a variety of ways. It is an important constituent of cell membranes, DNA, RNA and ATP. Heterotrophs (animals) obtain their phosphorus from the plants they eat, although one type of heterotroph, the fungi, excels at taking up phosphorus and may form mutualistic symbiotic relationships with plant roots. These relationships are called mycorrhizae; plants get phosphate from the fungus and give the fungus sugars in return. Animals may also use phosphorus as a component of bones, teeth and shells. When animals or plants die, the phosphate will be returned to the soil or water by the decomposers. There, it can be taken up by another plant and used again. This cycle will occur over and over until at last the phosphorus is lost at the bottom of the deepest part of the ocean, where it becomes

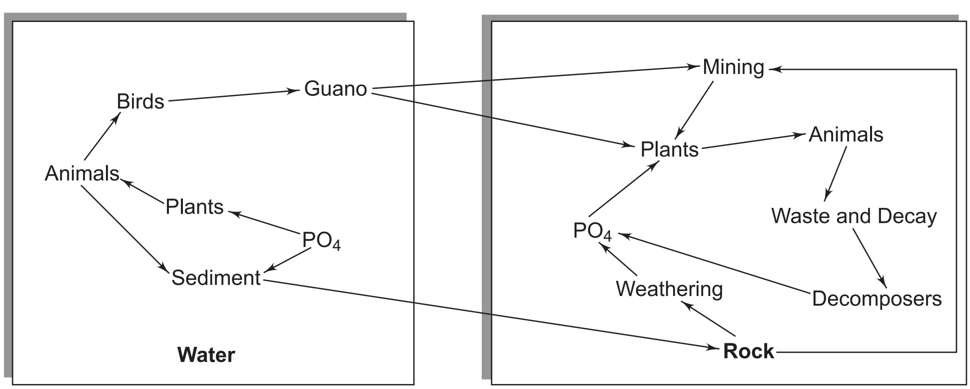


Fig. 3.17 *Phosphorus Cycle*

part of the sedimentary rocks forming there. This phosphorus will be released if the rock is brought to the surface and weathered.

3.16 SULPHUR CYCLE

Sulphur is mainly found on Earth as sulphates in rocks or as free sulphur. Sulphur also occurs in combination with several metals such as lead and mercury, as PbS and HgS. Sulphur appears as the yellow aspects of soil in many regions.

Sulphur and its compounds are important elements of industrial processes. Sulphur is also a biologically important atom. Sulphur is released into the atmosphere through the burning of fossil fuels, especially high sulphur coal. Sulphuric acid (H_2SO_4) is the primary constituent of acid rain. Sulphur dioxide and carbonyl sulfide (COS) occur in small quantities in the atmosphere; but due to its high reactivity, sulphur is quickly deposited as compound (sulfates) on land and other surfaces.

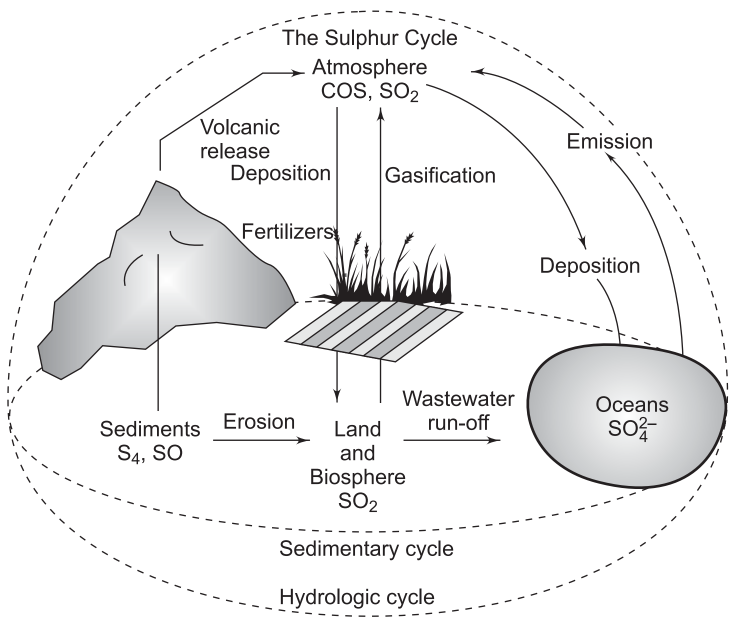


Fig. 3.18 *Sulphur Cycle*

3.17 FOREST ECOSYSTEMS

A healthy forest ecosystem is more than just trees. A forest also includes a diverse combination of herbaceous plants, shrubs, seedlings, and an abundance of birds, mammals, insects, reptiles, amphibians, and microscopic creatures. The species composition of forests varies from one place to another, even within the same woodland type.

3.17.1 Vertical Structure—Vegetation Layers

The vertical structure of the forest is divided into four distinct layers, each adapted to increasingly filtered sunlight. Not all forests have each layer (Fig. 3.19).

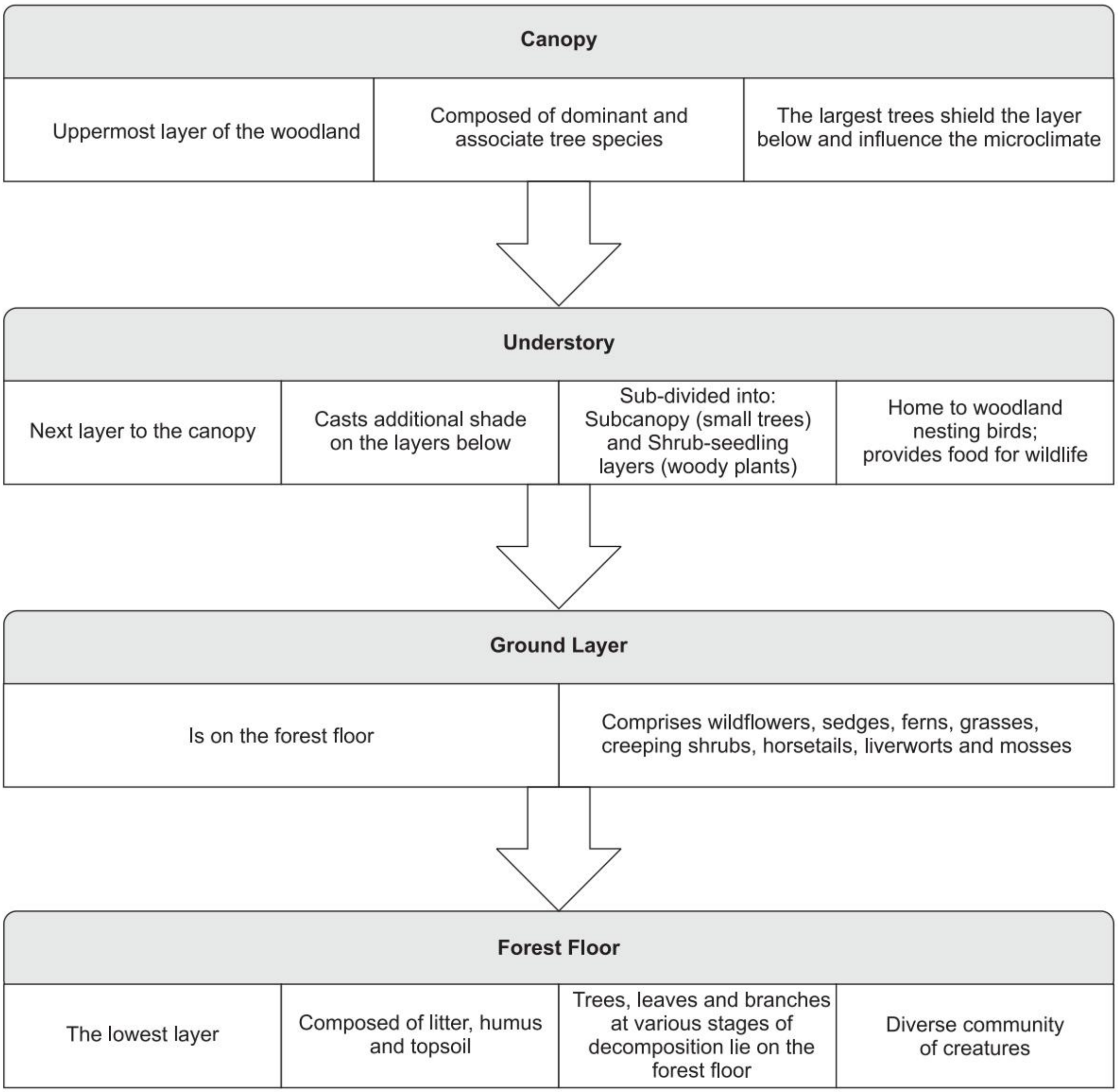


Fig. 3.19 *Vertical Structure of a Forest*

3.17.2 Horizontal Structure

The composition and distribution of species can vary widely from one spot to the next based on the following factors.

- Environmental gradients, such as moisture, drainage, slope, slope aspect, soil type, and light intensity.
- Gaps in the canopy where individual trees die from old age; disease; lightning strikes or storms.
- Seed availability.
- Large clearings created from widespread insect and disease damage; or destruction from fire. New generations of trees and shrubs fill in these gaps and clearings.

3.17.3 Environmental Influences

Plants and animals are influenced by each other and by the environment in a natural community.

❑ *Soil* The key soil-related factors affecting the type of community that will grow on a particular site are the following:

- Soil type
- pH which ranges from acid to alkaline
- Amount of organic content.

❑ *Moisture and Drainage* The amount of moisture available is another key determinant for the mix of species that will grow at a site. Woodland communities are classified as dry (xeric), dry-mesic, mesic, wet-mesic, and wet (hydric), based on the soil moisture.

❑ *Topography* The topography of the land, whether it is flat, hilly, upland or low-lying, further refines the composition of a woodland. Low areas, such as those along rivers or in depressions, support species adapted to wet conditions. High, dry uplands support species tolerant to drought.

The forests of the world are classified into the following broad categories:

1. Equatorial evergreen forest
2. Temperate deciduous forest
3. Northern coniferous forest

3.17.4 Forest Ecosystem Processes

In the forest ecosystem, successive levels of animal consumers, beginning with plant-eating herbivores and ending with several levels of carnivorous predators, form a complex food web. When primary producers and consumers are dead, their remains are decomposed by bacteria and other micro-organisms and the nutrients are recycled. Complex biogeochemical cycles have developed within forest ecosystem to recycle nutrients for reuse by the primary producers.

3.17.5 Biomass and Productivity

Forests have higher gross primary production (total photosynthetic carbon fixation) and net ecosystem production than any other type of ecosystem because of their large biomass. Hence, forests are considered as biotic reservoir of nutrients.

3.17.6 Functions of Forest Ecosystems

Forest ecosystem enhances water resources in both quantity and quality, because of their storage capacity and ecological cleansing action. The hydrological cycle depends upon forest ecosystem and encourages absorption rather than run-off on precipitation. Forests give shelter to wildlife and fish.

Forest ecosystem is considered as a pathway for the exchange and regulation of atmospheric gases, water and trace chemicals. The forest biomass above ground efficiently intercepts atmospheric particles and aerosols. The atmospheric pollutants move through leaves into forest ecosystem, which are very important to the balance of life on earth.

3.18 GRASSLAND ECOSYSTEMS

Hot and dry conditions at lower elevations create a treeless desert like shrub, grasses or grass like plants forming grassland and grassland ecosystems.

Grasslands are generally classified into the following types:

- Temperate grasslands (receiving 25–100 cm of annual precipitation)
- Tropical grasslands (receiving up to 150 cm of annual precipitation)
- Desert grasslands (receiving 25–45 cm of annual precipitation)

Grassland soils are highly fertile and contain large amount of exchangeable bases and organic matter.

Comparing forest soil, grassland soils are generally subjected to higher temperature, greater evaporation, periodic drought and more transpiration per unit of total plant biomass. Hence they are usually dry throughout the profile for a portion of the year, creating impervious subsurface layer and hence not supporting the big trees over grasses.

3.19 AQUATIC ECOSYSTEMS

Aquatic ecosystems exist in ponds, lakes, rivers, wetlands, etc. The components of an aquatic ecosystem are very diverse, but can be divided into several basic units.

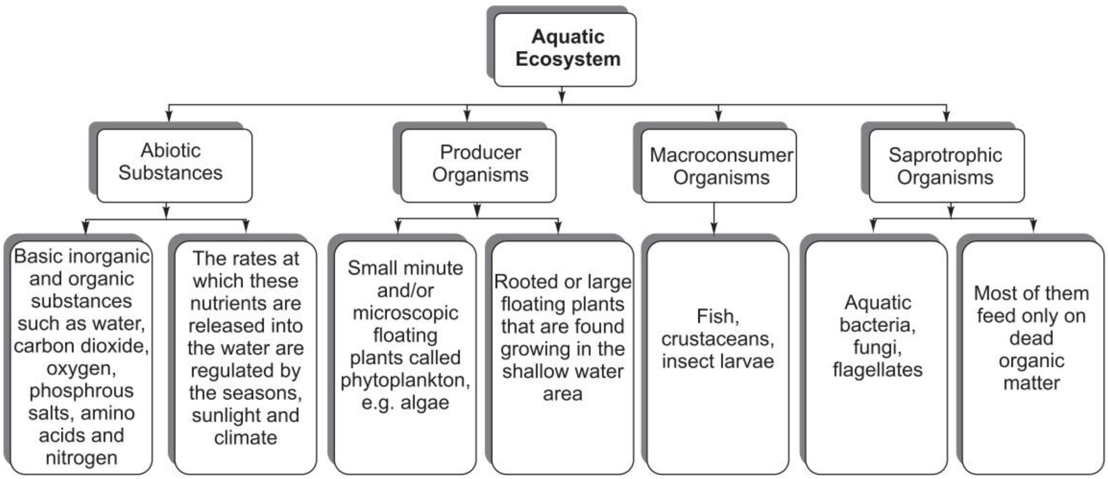


Fig. 3.20 *Aquatic Ecosystems—Structure and Functions*

3.19.1 Environmental Factors Affecting the Aquatic Ecosystem Performance

Figure 3.21 illustrates the environmental factors affecting the Aquatic Ecosystem performance.

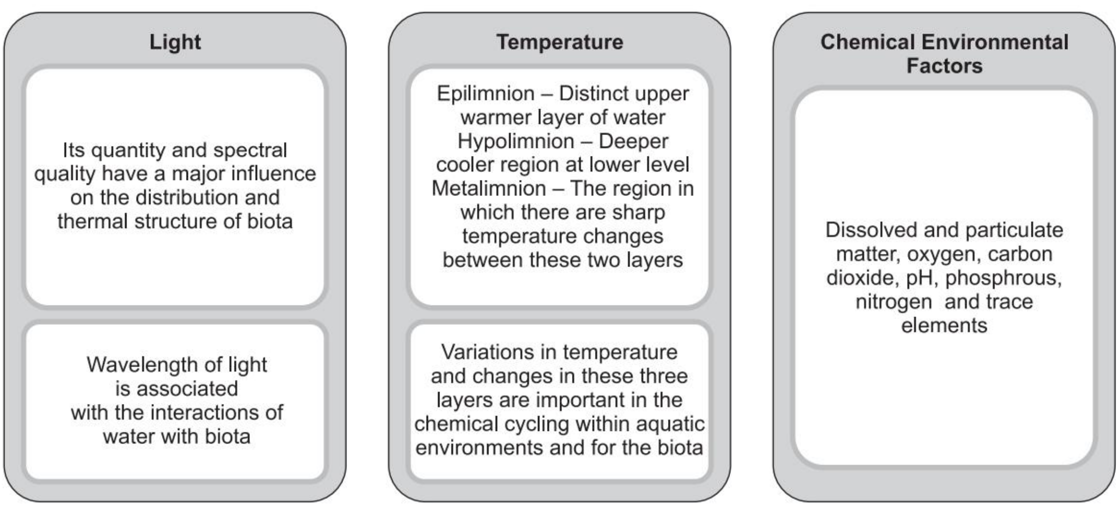


Fig. 3.21 *Environmental Factors Affecting the Aquatic Ecosystem Performance*

REVIEW QUESTIONS

Objective-Type Questions

1. Which of the following is a possible producer in an ecosystem?
(a) Plants and some bacteria capable of producing their own food
(b) Animals
(c) Human beings
(d) Fish

2. Which of the following statements is not true?
(a) In an ecosystem, sustained development (evolution) is facilitated by a close physical proximity and functional matching between the producers and the consumers.
(b) In the anthroposystem, there is usually a significant physical displacement between the producer and the consumer.
(c) In an ecosystem most of the materials are transferred from the producers to the recyclers and only a small fraction is passed through the consumers to the recyclers.
(d) In the anthroposystem the flow of material from the producers directly to the recyclers is a major proportion.

3. Which of the following statements is false?
(a) Inorganic nutrients are recycled in an ecosystem.
(b) Energy "flows" through the ecosystem in the form of carbon-carbon bonds.
(c) Energy is recycled in an ecosystem.
(d) Respiration process releases energy.

4. A food web consists of
(a) a portion of a food chain
(b) producers, consumers and decomposers
(c) interlocking food chains
(d) a set of similar consumers

5. A trophic level refers to
(a) area in the tropics
(b) an organism's position in a food chain
(c) an organism's position in an ecosystem
(d) an organism's position in a biome

6. The tendency of pollutants to become concentrated in successive trophic levels is known as
(a) bioremediation
(b) biomagnification
(c) biopiracy
(d) biorhythm

7. Which of the following is not a problem associated with agroecosystems?
(a) Creating a situation ideal for disease and insect pests.
(b) Lack of inorganic nutrient recycling.
(c) Increased water and energy consumption.
(d) Increased dependence on relatively a few varieties of plants for food.

8. Which of the following statements is not true?
(a) Reservoirs are those parts of the biogeochemical cycles where a chemical is held in large quantities for long periods of time.
(b) In exchange pools the chemicals are held only for a short time.
(c) The inorganic chemicals get recycled through both biological and geological worlds.
(d) Cloud is a reservoir of water.

9. The concentration of carbon in living matter is almost 100 times greater than its concentration in the earth because
(a) carbon is produced by the living cells.
(b) living things extract carbon from their nonliving environment.
(c) carbon is biomaginified in living cells.
(d) carbon cannot be recycled.

10. The largest reservoir of nitrogen on our planet is
(a) oceans
(b) atmosphere
(c) biosphere
(d) fossil fuels

11. What is Mycorrhizae?

(a) Symbiotic relationship between plants.
(b) Mutualistc associations between plant roots and fungi.
(c) A useful bacteria in carbon cycle.
(d) A useful bacteria in phosphorus cycle.

12. Which of the following are major players in phosphorus cycle?

(a) Human beings and fish
(b) Human beings and marine birds
(c) Fish and marine birds
(d) Animals and fish

13. Eutrophication is

(a) an improved water quality status of lakes.
(b) the result of accumulation of plant nutrients in water bodies.
(c) a process in the carbon cycle.
(d) a water purification technique.

14. Which of the following terminologies is not associated with the vertical structure of forest?

(a) Canopy
(b) Understory
(c) Forest floor
(d) First floor

15. The primary producers in a forest ecosystem are

(a) chlorophyll containing trees and plants
(b) herbivores
(c) carnivores
(d) bacteria and other micro-organisms

16. Most fertile and productive soils in the world have developed under grassland. What could be the reason for this?

(a) The rainfall in grasslands is inadequate and hence excessive leaching of minerals is blocked.
(b) The humus and partially decomposed organic materials expand its capability to retain water.
(c) Both (a) and (b).
(d) None of the above.

17. In an aquatic ecosystem, phytoplankton can be considered a

(a) consumer
(b) producer
(c) saprotrophic organisms
(d) macroconsumer

Short-Answer Questions

1. Define Ecology and Ecosystem.
2. Differentiate between biome and ecosystem.
3. List the major biomes of the world.
4. Differentiate between food chain and food web.
5. Define biomagnification.
6. Why don't water-soluble pollutants usually get biomagnified?
7. What is the relationship between oxygen cycle and carbon cycle?
8. Differentiate between reservoir and exchange pool in biogeochemical cycles.
9. What are the methods by which nitrogen fixation takes place in the nature?
10. List the reservoirs of phosphorus on earth.
11. Classify the grassland ecosystems based on precipitation.

Descriptive Questions

1. Explain the role of producers, consumers and decomposers in an ecosystem.
2. Compare and contrast an ecosystem with an anthroposystem.
3. Explain the flow of energy through the various components of the ecosystem (producers, consumers and decomposers).
4. Compare the flow of energy and nutrients through an ecosystem.
5. Explain the concept of ecological pyramid.
6. Explain how fat-soluble pollutants like DDT get biomagnified.
7. Compare and contrast natural ecosystem with agro ecosystem.
8. Explain the functioning of hydrological cycle.
9. With a neat sketch, explain how the element carbon is recycled in nature.
10. Explain the role of biogeochemical cycles in sustaining life on earth.
11. Explain the human influence on nitrogen cycle.
12. Explain the biogeochemical cycles of phosphorus and sulphur.

13. Discuss the practical ways and means of protecting the forest in the Indian context.

14. Explain the components and functions of a forest ecosystem.

15. Discuss the environmental factors affecting the performance of an aquatic ecosystem.

Answers to Objective-Type Questions

1. (a)	2. (d)	3. (c)	4. (c)	5. (b)	6. (b)	7. (c)
8. (d)	9. (b)	10. (b)	11. (b)	12. (b)	13. (b)	14. (d)
15. (a)	16. (c)	17. (b)				

4 BIODIVERSITY

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

Byran G. Norton

Learning Outcomes

On successful completion of this chapter, students will be able to:

➤ Discuss the significance, variations and value of biodiversity with examples.

➤ Describe the biodiversity of India with examples of endemic species and hotspots in biodiversity.

➤ Identify and list the endangered species of India and the major threats to biodiversity.

➤ Debate/evaluate the pros and cons of genetic engineering in the context of India.

4.1 INTRODUCTION

The term biodiversity refers to the totality of species, populations, communities and ecosystems, both wild and domesticated that constitute the life of any one area or of the entire planet. It may also be defined as the variety and variability among living organisms and the habitats in which they live.

The erosion of native biodiversity is manifested as species extinction, restriction of geographic range, unusual population fluxes, reproductive failures, and depletion of genetic diversity.

Over the course of time, human cultures have emerged and adapted to the local environment, discovering, using, and altering local biotic resources. Many areas that now seem "natural" bear the marks of millennia of human habitation, crop cultivation and resource harvesting.

Regeneration of habitat and reversing erosion of biodiversity is an extremely difficult and long process. Biodiversity is usually considered at three different levels.

- Genetic diversity
- Species diversity
- Ecosystem diversity

4.2 GENETIC DIVERSITY

Genetic diversity refers to the variation of genes within species.

Individuals belonging to a species share, by definition, certain characteristics, but genetic variations determine the particular characteristics of individuals within the species. It also determines whether an individual animal or plant has the ability to survive in a particular habitat or under particular environmental conditions.

There is high genetic variation in Indian rhinos, but little among cheetahs. Species that inhabit large areas and interbreed throughout the whole area have a high rate of gene flow and show few or no localized characteristics; however, species living in small or isolated areas have low rates of gene flow and, as they adapt over time to their particular environment, they develop into distinct, localized populations.

New genetic variation is produced in populations of organisms that can reproduce sexually by recombination and in individuals by gene and chromosome mutations.

Genetic variation is the raw material of evolution. Without genetic variation, a population cannot evolve in response to changing environmental variables and, as a result, will face an increased risk of extinction. For example, if a population is exposed to a new disease, selection will act on genes for resistance to the disease if they exist in the population. But if they do not exist, the population will not evolve and could be wiped out by the disease. For this reason, an endangered species with low genetic variation is at a greater risk of extinction. When the captive felines at an Oregon (US) breeding colony for large cats were exposed to a potentially deadly virus, it swept through the cheetah population, killing about 50 per cent but none of the lions (which has a greater genetic diversity than cheetah) even developed symptoms of any disease.

4.3 SPECIES DIVERSITY

Species diversity is the *number of species or the range of different types of species an area contains.*

There has been a definite bias towards describing large organisms, those that are considered attractive or appealing (such as flowering plants and butterflies), those most closely resembling humans (vertebrates, especially mammals), and those that have a direct impact on human activities (such as pests). Organisms that can be studied without complex procedures or expensive equipment have also taken precedence, as have those which are relatively easy to locate. This, however, underestimates the importance of microorganisms including algae, bacteria, fungi, protozoa and viruses, which are vital to life on Earth. At the ecosystem level, the greatest biomass in soil is microorganisms, especially fungi. These maintain soil structure and composition through biodegradation and incorporation of dead plant and animal remains. Clearly, the loss of microorganisms can lead to major changes in ecosystems.

4.4 ECOSYSTEM DIVERSITY

Ecosystem diversity encompasses the broad differences between ecosystem types, and the diversity of habitats and ecological processes occurring within each ecosystem type. Different physical settings favour very different communities of species. Ecosystems differ not only in the species composition of their communities, but also in their physical structures (including the structures created by organisms) and in what the species in their communities do.

The enormous range of terrestrial and aquatic environments on earth has been classified into a number of ecosystems and the following are a few examples:

- Tropical rainforests
- Grasslands
- Wetlands
- Coral reefs and mangroves

Measuring changes in the extent of ecosystems is difficult, because there is no globally agreed classification of ecosystems, and boundaries are often variable and elusive. Species contained within a given ecosystem also vary over time. Some of the world's richest habitats are tropical moist forests. Although they cover only 7 per cent of the world's surface, these areas contain at least 50 per cent of all plant and animal species.

4.5 VALUE OF BIODIVERSITY

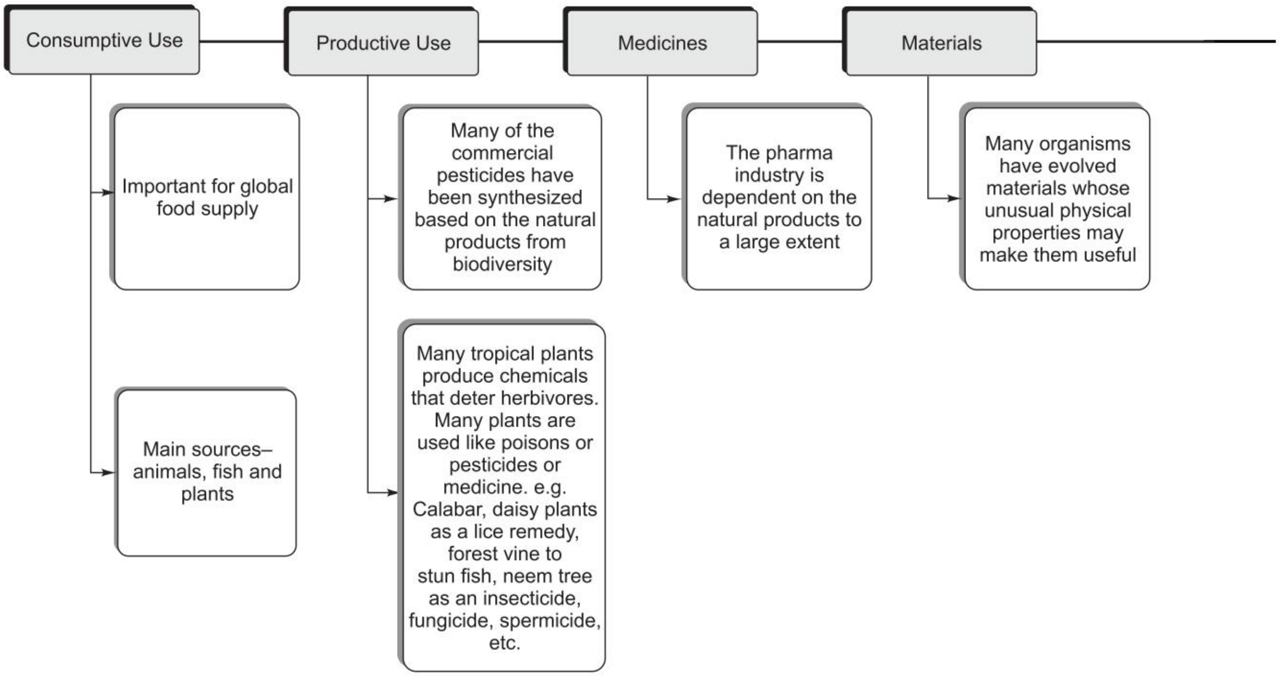
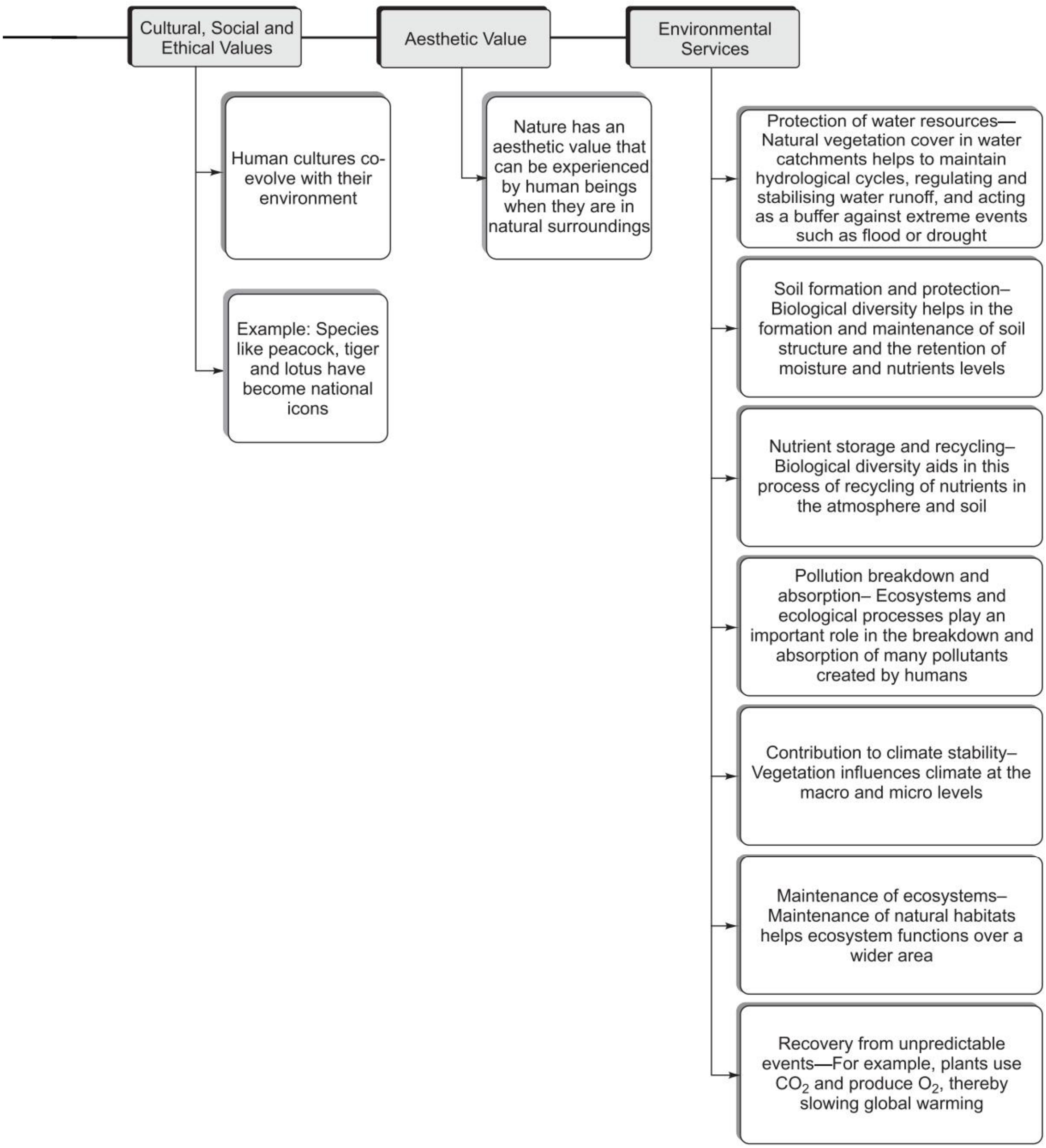


Fig. 4.1 *Value of Biodiversity*


Cultural, Social and Ethical Values
Aesthetic Value
Environmental Services
Human cultures co-evolve with their environment
Example: Species like peacock, tiger and lotus have become national icons
Nature has an aesthetic value that can be experienced by human beings when they are in natural surroundings
Protection of water resources—Natural vegetation cover in water catchments helps to maintain hydrological cycles, regulating and stabilising water runoff, and acting as a buffer against extreme events such as flood or drought
Soil formation and protection– Biological diversity helps in the formation and maintenance of soil structure and the retention of moisture and nutrients levels
Nutrient storage and recycling– Biological diversity aids in this process of recycling of nutrients in the atmosphere and soil
Pollution breakdown and absorption– Ecosystems and ecological processes play an important role in the breakdown and absorption of many pollutants created by humans
Contribution to climate stability– Vegetation influences climate at the macro and micro levels
Maintenance of ecosystems– Maintenance of natural habitats helps ecosystem functions over a wider area
Recovery from unpredictable events—For example, plants use CO_2 and produce O_2, thereby slowing global warming

4.6 VALUE OF GENES

Genetic engineering works with genes that have been isolated and analyzed at the molecular level, and the technology is still dependent on biological diversity to get the genes in the first place. All of the genetic variation present in wild populations is potentially useful for improvement of domestic animals and plants, and therefore should be preserved. The following is a list of such examples.

- A wild relative of the potato was found in Peru, and when it was hybridized with the standard crop plant, a variety was obtained that was resistant to potato blight.
- Rice grown in Asia is protected from the four main rice diseases by genes brought in from a wild species from India.
- In both India and Africa, yields of cassava (*tapioca*)—one of the most important root crops throughout the tropics—were increased 18-fold because of disease resistance brought in from wild Brazilian cassava.
- A wild tomato discovered in the Andes has been used to increase the sugar content of cultivated varieties, increasing their commercial value.

4.7 BIOPIRACY

Biopiracy is the practice of patenting and marketing the use of traditional knowledge and genetic resources of indigenous peoples without authorization from source countries. Unscrupulous investors have been trying to patent genetic varieties, often when it is clear that they have not "invented" anything, but are simply taking advantage of traditional knowledge.

CASE STUDY — ***The Basmati Patent Issue***

In late 1997, an American company RiceTec Inc. was granted a patent by the US patent office to call the aromatic rice grown outside India 'Basmati'. RiceTec Inc. had been trying to enter the international Basmati market with brands like 'Kasmati' and 'Texmati' described as Basmati-type rice with minimal success. However, with the Basmati patent rights, RiceTec will now be able to not only call its aromatic rice Basmati within the US, but also label it Basmati for its exports. This has grave repercussions for India and Pakistan because not only India will lose out on the 45,000 tonne US import market, which forms 10% of the total Basmati exports, but also its position in crucial markets like the E U, the UK, Middle East and West Asia. In addition, the patent on Basmati is believed to be a violation of the fundamental fact that the long grain aromatic rice grown only in Punjab, Haryana, and Uttar Pradesh is called Basmati. According to sources from the Indian newspaper, *The Economic Times*, "Patenting Basmati" in the US is like snatching away our history and culture.

(Contd.)

India and Pakistan who are joining hands to tackle the crisis have a strong case against RiceTec Inc. British traders are also supporting India and Pakistan. According to Howard Jones, marketing controller of the UK's privately owned distributor Tilda Ltd, "True Basmati can only be grown in India or Pakistan. We will support them in any way if it's necessary." The Middle East is also showing support by only labeling Indian or Pakistani rice as Basmati. The case is still unfolding and it will be interesting to find out what happens in the end, once the government and government agencies have gathered the necessary data and information to support their case and to prevent their cultural heritage from being taken away from them.

4.8 BIOGEOGRAPHICAL CLASSIFICATION OF INDIA

One of the major approaches to the classification of India's ecosystems has been based on biogeography. The major objective of this biogeographical classification based on scientific facts is to enable conservation planning, both at the national and state levels.

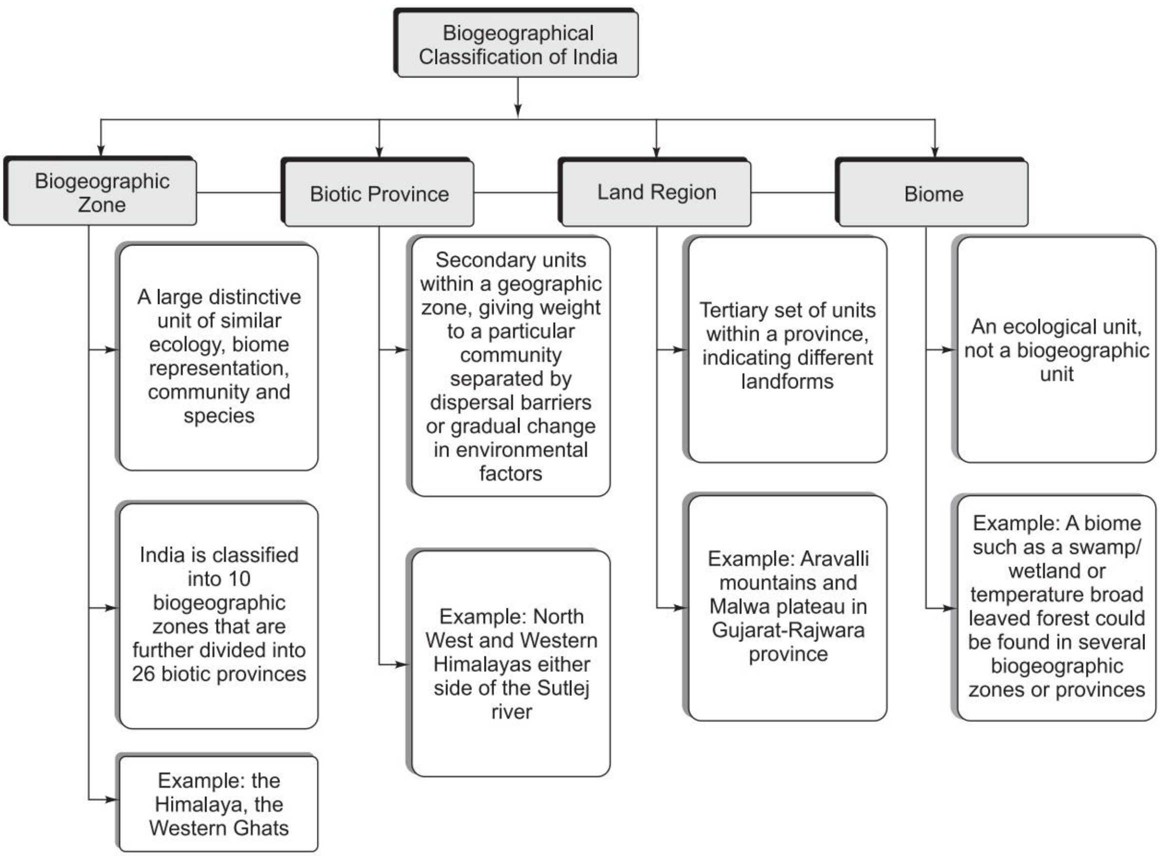


Fig. 4.2 *Biogeographical Classification of India*

4.9 INDIA AS A MEGA DIVERSE NATION

India has a rich and varied heritage of biodiversity, encompassing a wide spectrum of habitats from tropical rainforests to alpine vegetation and from temperate forests to coastal wetlands. India contains about 8% of the world's biodiversity on 2% of the Earth's surface, making it one of the 12 megadiversity countries in the world.

India, due to its varied physical features and its geographical location, experiences almost all kinds of climate, from tropical to alpine and from desert to humid.

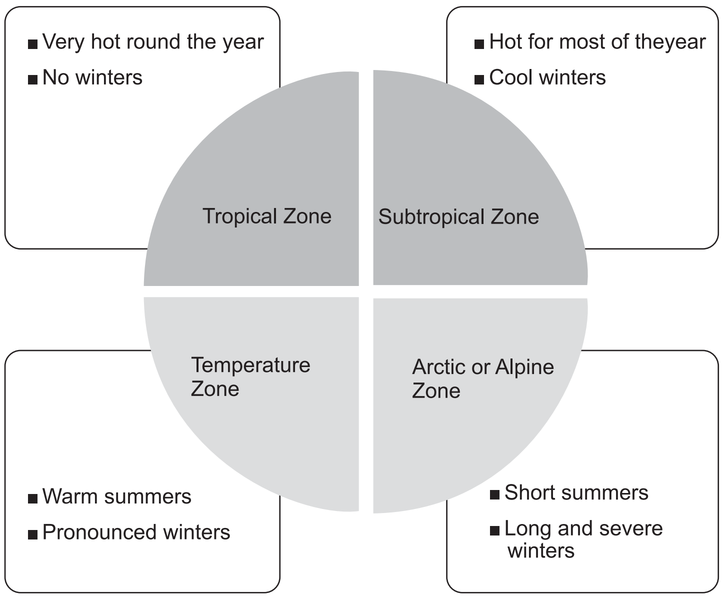


Fig. 4.3 *Classification of the Landmass of India based on Temperature*

The following is a list of important facts about the Indian biodiversity.

- India is home to 33% of the life forms found in the world and is one among the 12 megadiverse countries of the world.
- India comprises 2% of the world's landmass but is home to 8% of the biodiversity of the world.
- There are 33 botanical gardens, 89 national parks, 275 zoos, 504 sanctuaries and 18 biosphere reserves in India.
- 60% of this wealth can be found in the Western Ghats, which is one of the hotspots of diversity in India.

- India is a signatory to the international conventions like Convention of International Trade on Endangered Species (CITES) and Convention of Migratory Species (CMS) which aim at conserving biodiversity.
- India is home to 6 world heritage natural sites.
- India has two major realms called the Palaearctic and the Indo-Malayan, and three biomass, namely the tropical humid forests, the tropical dry/deciduous forests, and the warm desert/semi-deserts.

4.10 ENDEMIC SPECIES OF INDIA

Endemic species is a species native and confined to a certain region. Most species are rare and restricted, because their ecological requirements are only met over a small area and because they are not capable of dispersing great distances to other suitable habitats.

India has many endemic plant and vertebrate species. Areas rich in endemism are North-East India, the Western Ghats and the North-Western and Eastern Himalayas.

Endemism among mammals and birds is relatively low. Four endemic species of conservation significance occur in the Western Ghats and are listed below.

- Lion-tailed macaque (*Macaca silenus*)
- Nilgiri leaf monkey (*Trachypithecus johni*)
- Brown palm civet (*Paradoxurus jerdoni*)
- Nilgiri tahr (*Hemitragus hylocrius*)

Endemism in the Indian reptilian and amphibian fauna is high.

4.11 THREATS TO BIODIVERSITY

Human activities are endangering other species around the globe. Extinction is a part of the evolutionary process, but today's rate of extinction is much greater than the scale at which species disappear due to evolution alone.

In Earth's 5.5 billion year history, there have been five major "mass extinctions" recorded in the fossil record, the most recent of which, 65 million years ago, killed the last of the true dinosaurs. Scholars believe that we are currently experiencing extinction rates rivaling or exceeding the rates of the prehistoric mass extinctions. Although 99.9% of all animals that once lived on Earth are now extinct, the mass destruction attributable to one species (human beings) is apparently unique in the earth's history.

Habitat Degradation and Habitat Loss	■ As deforestation proceeds in tropical forests, mass exitinctions happen ■ Habitat fragmentation is a further aspect of habitat loss ■ Species like grizzly bear that require a large home range will not survive if their home area is reduced
Invasion of Non-Native Species	■ Addition or removal of even one species affects the whole biological system ■ Domino effects are likely when two or more species are highly inter-dependent, or when the affected species is a 'keystone' species ■ For example: A very few of the Calvaria major trees of Mauritius survive today because of their dependence on the Dodo, which was hunted to extinction
Pollution	■ Many plants and animals have become extinct as a result of direct poisoning or the degradation of the environment and other dependent species
Over-Exploitation of Resources	■ Logging, hunting and fishing have reduced many species to extinction ■ Individual species are often targeted for their value as a commodity
Global Environmental Change	■ Climate change threatens organisms and ecosystems, which may not adapt quickly enough to changing environmental conditions

Fig. 4.4 *Threats to Biodiversity*

4.12 HOTSPOTS OF BIODIVERSITY

Hotspots are areas that are extremely rich in species, have high endemism, and are under constant threat. Plant diversity is the biological basis for hotspot designation. To qualify as a hotspot a region must satisfy the following conditions.

- Must support 1500 endemic plant species, 0.5% of the global total. Existing primary vegetation is the basis for assessing human impact in a region;
- Must have lost more than 70% of its original habitat.

Today, the fast growing human populations in the hotspots contribute to their deterioration by the following actions:

- Introduction of exotic species
- Illegal trade in endangered species
- Industrial logging
- Slash and burn agricultural practices
- Mining
- Construction of highways, dams, and oil wells

Indo-Burma and Western Ghats/Sri Lanka are the identified biodiversity hotspots of India.

4.12.1 Hotspots in India

Among the 25 hotspots of the world, two are located in India extending into neighbouring countries the Indo-Burma region (covering the Eastern Himalayas) and the Western Ghats/Sri Lanka. These areas are particularly rich in floral wealth and endemism, not only in flowering plants but also in reptiles, amphibians, swallow tailed butterflies, and some mammals.

4.13 ENDANGERED SPECIES OF INDIA

India contains 215 species of animals considered globally threatened by International Union for Conservation of Nature and natural resources (IUCN). India contains globally important populations of some of Asia's rarest animals, such as the Bengal Fox, Asiatic Cheetah, Marbled Cat, Asiatic Lion, Indian Elephant, Asiatic Wild Ass, Indian Rhinoceros, Markhor, Gaur, Wild Asiatic Water Buffalo, etc.

A description of the few of the important endangered endemic species of India is given below.

The Lion-Tailed Macaque (Macaca silenus)

Western Ghats, in peninsular India is home to a variety of organisms, many of which are endemic to this ancient hill range. One such is the lion-tailed, macaque, *Macaca silenus*, an endangered primate. Even within the Western Ghats, this animal has a limited distribution. It is restricted to the Western Ghats of South India where it is found only in the wet evergreen forests and some shoals.

The lion-tailed macaque is the only Indian macaque with a black coloured coat.

The meat of these macaques is supposed to have medicinal value. Hence, they are hunted for their meat, besides their skin. Poaching and destruction of its evergreen forest habitat are major threats to the survival of this species.

The Asiatic Lion (Panthera leo persica)

The Asiatic lion, *Panthera leo persica*, like its African counterpart, lives in prides and is the most social among cats. The members of the pride often hunt together.

Though once widespread throughout South–West Asia from Northern Greece to Central India, its numbers declined with the disappearance of the scrub and grasslands. Today, the Asiatic lion is restricted to Gir National Park, Gujarat, in India—its last refuge with a mixed deciduous forest.

Lions have played an important role in the folklore of Indian culture for over 2000 years and have been celebrated as Lord of Beasts. Emperor Ashoka used the lion as a symbol of power and strength. This depiction of the lion eventually has become the symbol of the modern Republic of India.

4.14 CONSERVATION OF BIODIVERSITY

In 1999, the Ministry of Environment and Forests prepared a National Policy and Macro level Action Strategy on Biodiversity through a consultative process and formulated a macro-level statement of policies, gaps and strategies needed for conservation and sustainable use of biological diversity.

4.14.1 In-situ and Ex-situ Conservation

Conservation can broadly be divided into in-situ and ex-situ conservation. *In-situ means 'on site', hence the in-situ conservation is the conservation of species diversity within normal and natural habitats and ecosystems.* Whereas *in ex-situ conservation the biodiversity is conserved out of their natural habitats.* Zoos, botanical gardens and seed banks are examples of ex-situ conservation.

4.14.2 Preservation and Conservation

The terms *preservation* and *conservation* are often understood in the same sense but confused, but there is a difference between them. *Preservation* implies complete protection, and leaving the natural resources totally untouched. *Conservation* implies the management of resources on a sustainable yield basis.

Thus conservation is the process of protecting the environment while taking reasonable benefits out of it without causing major damages to it. For example, in animal populations safety does not lie entirely in numbers. Wildlife sometimes can be overprotected. The results of allowing a deer herd, deprived of its natural predators, to multiply beyond the carrying capacity of its habitat have been documented in the past. Poor growth, weakened physical condition, and starvation are sure to follow. The severely damaged forest takes many years to recover, reducing its value for not only deer, but other wildlife as well.

4.14.3 Project Tiger

This project was launched in 1972 to save the tiger from the brink of extinction. The tiger is at the apex of the ecological pyramid. Thus the wellbeing of the tiger is synonymous with the health of the ecosystem.

4.14.4 Project Elephant

The government of India launched this project in 1991-92 with the objective of saving the Asiatic elephant. The project covers the major elephant populations extending over 12 states.

Besides this in-situ conservation measures, India has a comprehensive ex-situ conservation programme. There are 33 botanical gardens, 275 zoos, deer parks, safari parks, acquaria, etc. A number of premier bodies like Zoological Survey of India, Botanical Survey of India and institutes like Wild Life Institute of India, Indian Council for Forestry Research and Education, Indira Gandhi National Forest Academy, Salim Ali School of Ornithology are engaged in wildlife education and research.

4.15 GENETIC ENGINEERING AND BIODIVERSITY

The introduction of genetically engineered (GE) organisms or genetically modified organisms (GMO) into complex ecosystems is a dangerous global experiment with nature and evolution. Genetic scientists are altering life itself, the products of the technology are living organisms that could never have evolved naturally and which don't have a natural habitat. GMO can reproduce and interbreed with wild organisms and therefore spread to new environments and future generations in an unpredictable and uncontrollable way.

The following is a list of arguments and examples cited against GMO worldwide and this may not be interpreted as the personal views of the author.

- Genetic pollution, by transferring foreign genes to related organisms, may be passed on to all future generations of life. Damage caused by releasing GE organisms into the environment in many cases would be irreversible.

- Pose new risks to ecosystems, with the potential to threaten biodiversity, wildlife and sustainable forms of agriculture.
- Genetic engineering of food is an inherently risky process. Current understanding of genetics is extremely limited and scientists do not know the long-term effects of releasing these unpredictable foods into our environment and our diets. Yet, genetically engineered (GE) ingredients are freely entering our food without adequate safeguards in place and without explicit consumer consent and knowledge.
- A precautionary approach to public health and safety is necessary where risks are unknown; such products or processes should not be deployed.
- Although international companies and their political supporters want us to believe that GE food is safe and thoroughly tested, growing awareness about its threats has sparked a global wave of rejection by consumers, farmers and food companies in many of the world's largest food markets.
- Biological diversity is experiencing a dangerous wave of privatisation under the label of 'intellectual property rights' such as patenting of plants, animals and individual parts of DNA. Patents should be granted only to human inventions, not discoveries. Existing living organisms, like plants and animals as well as their genes are no one's invention and should therefore never be patented and put under private control. However, over the past decades patent claims on plants and animals as well as genes and parts of human bodies have been continuously extended by industry and patent offices of industrialized countries.
- By patenting life now, the genetic engineering industry gains control not only over its own genetically engineered organisms, but also over the food chain and the planet's own future genetic heritage. Patenting allows industry to take control of and exploit organisms and genetic material as exclusive private property that can be sold to or withheld from farmers, breeders, scientists and doctors.
- In developing nations, from where most global food crops originate, freely available seeds and specimens are analysed by genetic engineering companies, patented and then sold back to them at higher prices.
- There are many ways in which genetic material can spread and cause genetic pollution: the wind, bees (flies, butterflies, ants, beetles and aphids), cross pollination, horizontal gene transfer, human handling, crop transport and holding facilities.
- GE crops can cross pollinate with wild and weedy relatives of crop. This can cause the extinction of rare wild relatives and the evolution of aggressive weeds, which may express the engineered trait.

- Engineered genes can transfer to the gut of other species. GE genes could transfer from parts of a GE plant to the gut of other species following ingestion, e.g. to pollinators, humans, cattle, farmed fish, birds and wildlife. This may also occur through pathogens (for example viruses) and may transfer into soil microorganisms.
- Genetic engineering can confer new allergic potential to everyday foods. A good example is when soyabeans were genetically engineered with a gene from a Brazil nut. Tests on blood taken from individuals allergic to Brazil nuts unexpectedly revealed that they had a similar allergic reaction to the GE soyabean.
- Scientists have inserted the insecticidal bacterium *bacillusthuringiensis* (Bt) into the DNA of corn, cotton and potatoes to deter or kill Lepidoptera and Coleoptera, including bollworm in cotton, stem borers in corn and the colourado potato beetle in potatoes. In essence, the plants are insecticides.
- Farmers must pay more to grow genetically modified crops.
- Those who grow food organically—which is to say that they avoid using synthetic pesticides and fertilizers—are concerned about this issue. International standards disallow the presence of transgenic traits in such crops. But that hasn't stopped GMOs from contaminating organic crops, just as they have done to conventional varieties.

REVIEW QUESTIONS

Objective-Type Questions

1. Genetic variation between distinct populations of the same species is known as

(a) species diversity (b) ecosystem diversity
(c) genetic diversity (d) biodiversity

2. Which of the following is not a world heritage site?

(a) Manas Wildlife Sanctuary (b) Nanda Devi National Park
(c) Kaziranga National Park (d) Periyar National Park

3. Which of the following is an endemic species of India?

(a) Asian elephant (b) Lion-tailed macaque
(c) Whales (d) Panda

4. Which of the following is a biodiversity hotspot in India?
(a) Gulf of Mannar (b) Western Ghats
(c) Pachmarhi (d) Sunderbans

5. Which of the following is an in-situ conservation measure taken by India?
(a) Project Elephant (b) Project Lion
(c) Project Rhino (d) All of these

6. Who introduced the concept of biodiversity hotspot?
(a) Christopher Columbus (b) Norman Myers
(c) WWF (d) Charles Darwin

7. Lion-tailed macaque is found in
(a) Western Ghats (b) Eastern Ghats
(c) Caucasus (d) Western Himalayas

8. Which of the following is a cause of loss of biodiversity?
(a) Habitat degradation and loss (b) Invasion of non-native species
(c) Pollution (d) All of these

9. The dodo was extinct due to
(a) pollution (b) invasion of non-native species
(c) over-exploitation of resources (d) global environmental change

10. Spot the site, which is not a biodiversity hotspot.
(a) Brazil's Cerrado (b) Central Chile
(c) California Floristic Province (d) Pakistan

Short-Answer Questions

1. Define *biodiversity*.
2. Differentiate between *genetic diversity* and *species diversity*.
3. List the environmental services offered by biodiversity.
4. What is meant by the term *biopiracy*?
5. List the biogeographical zones of India.
6. Enumerate the biosphere reserves of India.
7. Explain the term *endemic species* with examples.

8. Identify the endemic species of flora and fauna found nearest to your locality.
9. Define the term *hotspot* in biodiversity.
10. Enumerate the biodiversity hotspots identified in India.
11. Give examples of the endangered species of India.

Descriptive Questions

1. Classify the types of biodiversity and explain in detail with examples.
2. What is the importance of protecting the biodiversity of earth?
3. With examples explain the value of genes.
4. Explain the biogeographical classification of India.
5. Discuss the status of India as a mega diverse nation of biodiversity.
6. Mention the important sites in India identified for the conservation of endemic species and list the major endemic species of India.
7. Extinction is part of the evolutionary process. Still why should we bother about the ongoing species extinction?
8. Identify and explain the present-day major threats to the biodiversity of India.
9. Explain the efforts taken towards conservation of biodiversity in India.
10. Is biotechnology a threat to biodiversity? Substantiate your answer with examples.

Answers to Objective-Type Questions

1. (c)	2. (d)	3. (b)	4. (b)	5. (a)	6. (b)	7. (a)
8. (d)	9. (b)	10. (d)				

5 ENVIRONMENTAL POLLUTION

"A nation that destroys its soils destroys itself. Forests are the lungs of our land, purifying the air and giving fresh strength to our people."

Franklin Roosevelt

Learning Outcomes

On successful completion of this chapter, students will be able to:

- ➤ Summarize the causes, effects and control measures for air and water pollution.
- ➤ Identify the causes, effects and control measures for soil, marine, thermal and noise pollution.
- ➤ Recall and illustrate the municipal Solid Waste and Hazardous Waste Management strategies.

5.1 AIR POLLUTION

5.1.1 General

Air pollution is the presence in the air of substances generally originating from the activities of humans in sufficient concentrations and sufficient duration to interfere with the health, comfort, safety or full use and enjoyment of property.

5.1.2 Sources of Air Pollution

The sources of air pollution can be broadly classified into natural and anthropogenic. The natural sources include volcano, forest fire and pollens. The anthropogenic sources include everything involving human activities. The other major classifications are shown in Fig. 5.1.

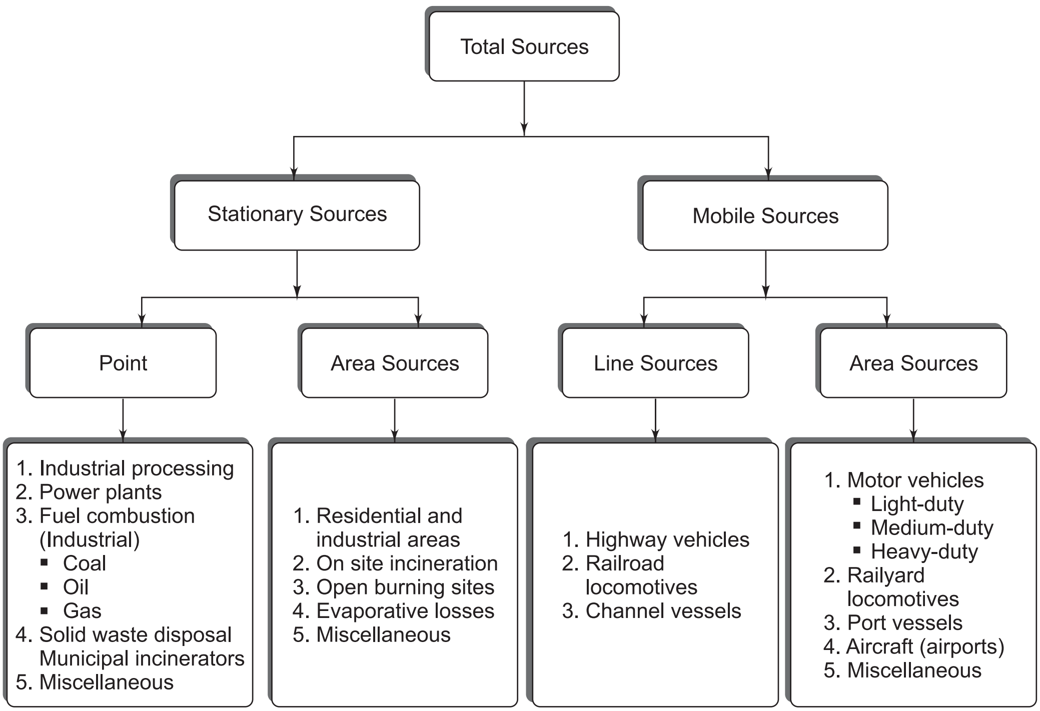


Fig. 5.1 *Classification of Air Pollution Sources*

5.1.3 Major Air Pollutants

The sources, effects and characteristics of some of the major air pollutants are shown in Fig. 5.2.

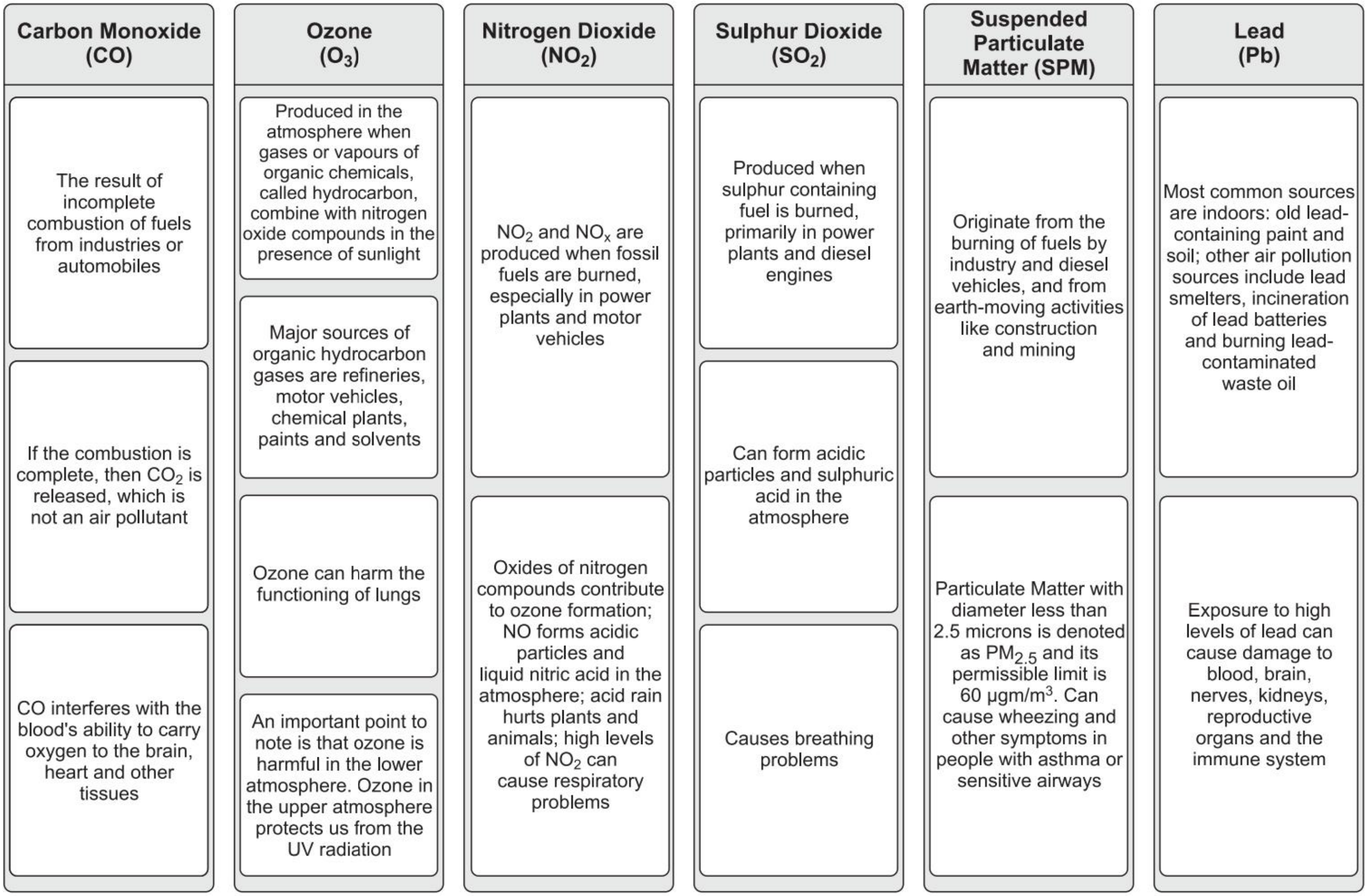


Fig. 5.2 *Major Air Pollutants*

5.1.4 Effect of Air Pollution on Animals, Plants and Property

Animals

- Similar to that of human beings
- Accumulation of airborne contaminants on the vegetation; when animals consume this, they get poisoned
- Reduction in yield from cattle
- Symptoms include lack of appetite, rapid weight loss, lameness, diarrhoea and subsequently death

Plants

- Mainly, the leaves get affected
- Symptoms:
  - Necrosis – Killing or collapse of tissue
  - Chlorosis – Reduction in the chlorophyll
  - Abcission – Dropping of leaves
  - Epinasty – Downward curvature of leaves due to higher rate of growth on the upper surface

Building Materials and Metals

- Leads to erosion and corrosion
- Corrosion of building materials due to acid rain and ozone. e.g., the Taj Mahal
- Subsequently, leads to economic loss

Fig. 5.3 *Effects of Air Pollution*

5.1.5 Toxic Air Pollution

Toxic air pollution, also referred to as hazardous air pollution, is due to those substances in the air which are known or suspected to cause cancer, genetic mutation, birth defects or other serious illnesses in people even at relatively low exposure levels.

CASE STUDY

Bhopal Tragedy

Bhopal is the site of the greatest industrial disaster in history. On the night of December 23, 1984, a dangerous chemical reaction occurred in the Union Carbide factory when a large amount of water got into the Methyl Isocyanate (MIC) storage tank. The leak was first detected by workers about 11:30 p.m. when their eyes began to tear and burn. They informed their supervisor who failed to take action until it was too late. In that time, a large amount (about 40 tons) of MIC, poured out of the tank for nearly two hours and escaped into the air, spreading within 8 km downwind, over the city of nearly 900 000. Thousands of people were killed (estimates ranging as high as 4 000) in their sleep or as they fled in terror, and hundreds of thousands remain injured or affected (estimates range as high as 400 000) to this day. This poisonous gas caused death and left the survivors with lingering disability and diseases.

5.1.6 Primary and Secondary Air Pollutants

Primary air pollutants are the ones that are emitted from a specific source, e.g. carbon monoxide or nitrogen dioxide whereas the secondary air pollutants are the ones formed in the atmosphere as a result of the interactions between the primary air pollutants, e.g. ozone and PANs (Peroxy acetyl nitrates).

5.1.7 Smog

Smog is a combination of smoke and fog. It is caused by chemical reactions between pollutants derived from different sources, primarily automobile exhaust and industrial emissions.

Long-term health effects of smog can include chronic respiratory disease, lung cancer, heart disease, and even damage to the brain, nerves, liver, or kidneys.

5.1.8 Photochemical Smog

Photochemical smog is a mixture of pollutants which includes particulates, nitrogen oxides, ozone, aldehydes, peroxy acetyl nitrates (PAN), unreacted hydrocarbons, etc. The photochemical smog often has a brown haze due to the presence of Nitrogen Dioxide.

Effects of Photochemical Smog

1. It can cause headaches, eye, nose and throat irritations. It may cause the lung function impaired, coughing and wheezing.
2. It can cause rubber and fabrics to deteriorate.
3. It can damage plants, leading to the loss of crops.

5.1.9 Automobile and Air Pollution

Automobiles are a major source of air pollutants such as carbon monoxide and oxides of nitrogen. Table 5.1 shows the major air pollutants emitted by the automobiles and their effects.

Table 5.1 *Potential Harmful Effects of Automobile Exhaust Pollutants*

Pollutant	***Health effects***	***Environmental effects***
Carbon Monoxide (CO)	Lethal at high doses. At low dose can impair concentration and neuro-behavioural function. Increases the likelihood of exercise-related heart pain in people with coronary heart disease.	Greenhouse gas contributing to global warming.
Nitrogen Oxides (NOx)	Cause asthma and possibly increase susceptability to infections.	Acid rain. An ingredient for the formation of photochemical fog.
Hydrocarbons (HC)	Low molecular weight compounds cause eye irritation, coughing and drowsiness. High molecular weight compounds can be mutagenic or carcinogenic.	An ingredient for the formation of photochemical fog.
Benzene (C_6H_6)	Classified as a human carcinogen by the International Agency for Research on Cancer.	Not known.
Ground-level ozone (O_3)	Irritates the eyes and air passages. Increases the sensitivity of the airways to allergic triggers in people with asthma. May increase susceptibility to infection	Oxidants to plants, impairs growth and maturation.
Lead (Pb)	Impairs the normal intellectual development and learning ability of children.	Ground water pollution and particulates in air.

5.1.10 Air Pollution Control Technologies

The selection of air pollution control device is based on factors such as characteristics of the air pollutant and the desired removal efficiency. Figure 5.4 shows some of the popular air pollution control devices and their salient features.

Cyclone Separator	Bag Filter	Electrostatic Precipitator (ESP)	Absorption and Wet Scrubbing Equipment	Catalytic Converter
■ Employed to collect large size particulate matter from a gaseous stream through the use of centrifugal forces ■ Dust-laden gas is made to rotate in a decreasing diameter pathway, forcing solids to the outer edge of the gas stream for deposition into the bottom of the cyclone	■ Separates and collects coarse particulates generated in the machining and treatment process of bulk material, and exhausts clean air ■ Of use in the food, chemical and other such industries where bulk material is dealt with	■ Removes fine particles contained in an exhaust gas by electrostatical principle ■ Removes fine particles contained in an exhaust gas by electrostatical principle ■ Used for the removal of finest dust particles that cannot be removed by other equipment ■ Used for the removal of finest dust particles that cannot be removed by other equipment	■ Removes gases and particulate matter from an exhaust stream by dissolving gaseous contaminants in the liquid stream and by entrapping solids in the liquid	■ Converts CO to CO_2, hydrocarbons to water and oxides of nitrogen are converted to nitrogen

Fig. 5.4 *Air Pollution Control Devices*

Cyclone Separator

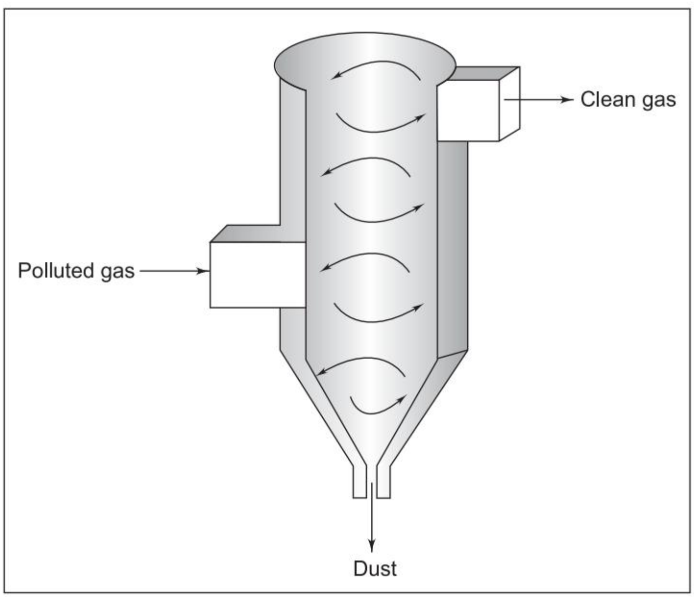


Fig. 5.5 *Cyclone Separator*

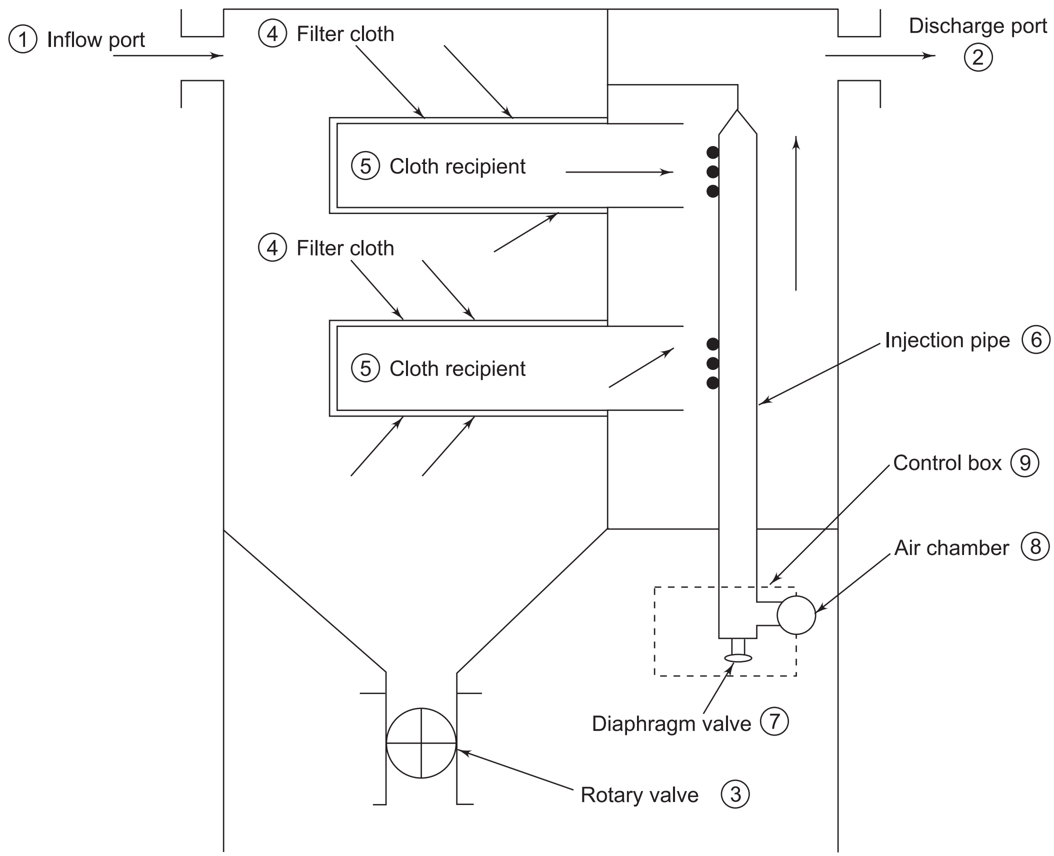


Fig. 5.6 *Bag Filter Working*

Electrostatic Precipitator (ESP)

The purpose of the electrostatic precipitator is to remove the fine particles contained in an exhaust gas by electrostatical principle as an air pollution preventing equipment. Electrostatic precipitators are used for the removal of finest dust particles that cannot be removed by other equipments such as cyclone separators and fabric filters.

Principle The fine dust particles are charged and collected by electrostatical principle. In the case of dry type, the collected dust is removed by rapping device and in the case of wet types the collected dust is removed by washing device.

Absorption and Wet Scrubbing Equipment (Wet Scrubber)

The goal in absorption and wet scrubbing equipment is the removal of gases and particulate matter from an exhaust stream by dissolving the gaseous contaminants in the liquid stream and by entrapping the solids in the liquid.

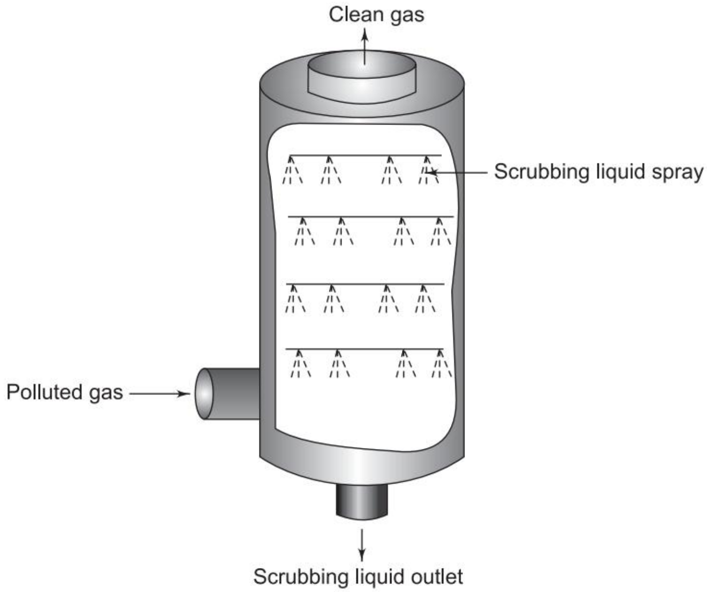


Fig. 5.7 *Wet Scrubber*

5.1.11 Catalytic Converter

Catalytic convertors are generally used in automobiles to treat the air pollutants in the exhaust gas. Figure 5.8 shows the working of a catalytic convertor which converts carbon monoxide to carbon dioxide and nitric oxide to nitrogen gas.

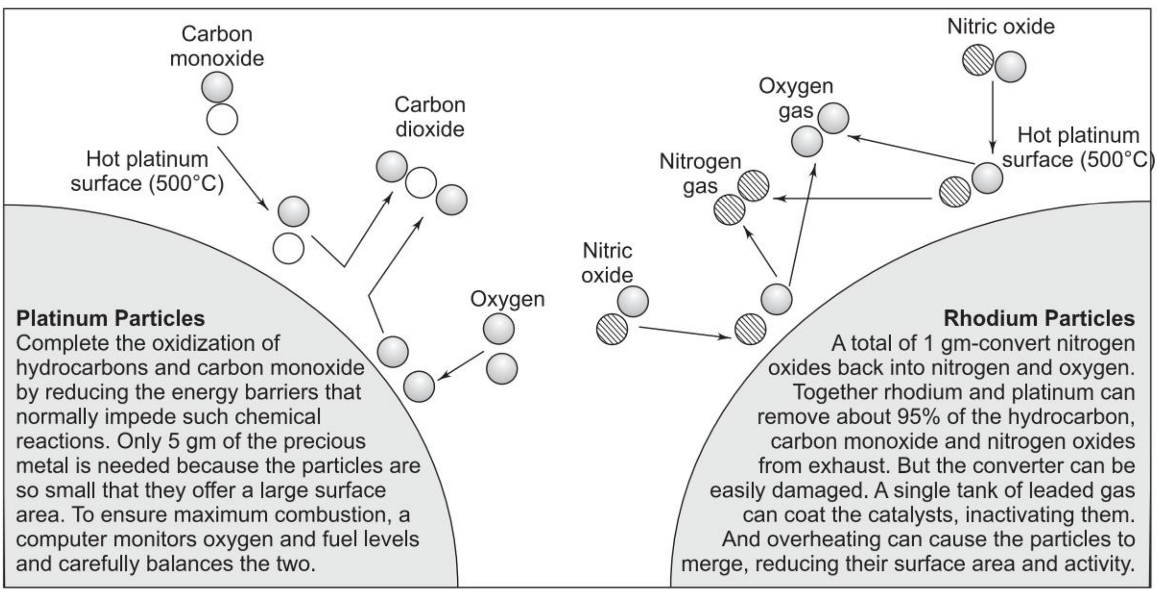


Fig. 5.8 *Working of Catalytic Converter*

5.2 WATER POLLUTION

Water around the world is getting polluted due to human activities and the availability of potable water in nature is becoming rare day by day.

5.2.1 Major Forms of Water Pollution

❑ *Disease-causing agents* Bacteria, viruses, protozoa and parasitic worms that enter water from domestic sewage and animal wastes.

❑ *Oxygen-demanding wastes* Organic wastes, which can be decomposed by oxygen-consuming bacteria. Large populations of bacteria supported by these wastes can deplete water of dissolved oxygen gas.

❑ *Water-soluble inorganic chemicals* Acids, salts, and compounds of toxic metals such as lead and mercury. Such dissolved solids can make water unfit to drink, harm fish and other aquatic life, decrease crop yields, and accelerate corrosion of equipment that uses water.

❑ *Inorganic plant nutrients* Water soluble nitrate and phosphate compounds that can cause excessive growth of algae and other aquatic plants, which then die and decay, depleting water of dissolved oxygen and killing fish.

❑ *Organic chemicals* Oil, gasoline, plastics, pesticides, cleaning solvents, detergents and many other water soluble and insoluble chemicals that threaten human health and harm fish and other aquatic life.

❑ *Sediment or suspended matter* Insoluble particles of soil and other solid inorganic and organic materials that become suspended in water and that in terms of total mass are the largest source of water pollution. Suspended particulate matter clouds the water, reduces the ability of some organisms to find food, reduces photosynthesis by aquatic plants, disrupts aquatic food webs, and carries pesticides, bacteria and other harmful substances.

❑ *Radioactive substances* Radioisotopes that are water soluble or capable of being biologically amplified to higher concentrations as they pass through food chains and webs.

❑ *Heat* Large quantity of water is heated when it is used in the cooling towers of thermal power plants. When this hot water is discharged into the nearby water bodies, it causes an increase in its temperature. This increase in water temperature lowers dissolved oxygen content and makes aquatic organisms more vulnerable to disease, parasites and toxic chemicals.

5.2.2 Sources of Water Pollution

The following are the present major sources of surface and ground water pollution in India.

- Industrial effluents
- Domestic sewage
- Fertilizers and pesticides from agricultural lands
- Leachate from solid waste disposal sites

5.2.3 Point and Non-point Sources

Point sources discharge pollutants at specific locations through pipes, ditches, or sewers into bodies of surface water. Examples include factories, sewage treatment plants (which remove some but not all pollutants), active and abandoned underground coal mines, off shore oil wells, and oil tankers.

Non-point sources are big land areas that discharge pollutants into surface and underground water over a large area, and parts of the atmosphere where pollutants are deposited on surface waters. Examples include runoff into surface water and seepage into the ground from croplands, livestock feedlots, logged forests, urban and suburban lands, septic tanks, construction areas, parking lots, roadways and acid deposition.

5.2.4 Ground Water Pollution and its Control

Ground water is a vital source of water for drinking and irrigation all over the world. Its use is expected to increase because of increasing population, irrigation, and industrialization. But this vital form of earth capital is easy to deplete because it is renewed at a very slow rate. Also, on a human time scale, ground water contamination can be considered permanent. Any waste disposed on land is likely to find its way to the ground water in due course.

5.2.5 Management of Municipal Sewage

Sewage is the wastewater generated from residential areas and it generally consists of wastewater from kitchens, bathrooms and toilets. It is necessary to collect, treat and safely dispose of the sewage, because if it is let into the environment without treatment, it will be naturally drained by the existing ground slope and will reach the nearby water bodies such as lakes and rivers. The organic waste present in the sewage will undergo decomposition in the water bodies causing depletion of dissolved oxygen in it and causing unhygienic conditions leading to the spread of water-borne diseases.

A few commonly used terms associated with the wastewater management are listed below.

- ***Sewer*** The pipeline or conduit carrying the sewage.
- ***Sewage*** Sewage is the liquid flowing in a sewer. Unless otherwise specified it refers to domestic sewage.
- ***Sullage/Grey water*** The wastewater generated from kitchens and bathrooms.
- ***Sanitary sewage/domestic sewage*** Wastewater generated from residential areas, the term sewage generally refers to sanitary sewage.

Systems of Sewerage

At many places in India, the pipe/channel which collects and conveys the wastewater from the households overflows during rains as rainwater drained from the roads and surroundings enters these pipes. This creates a highly unhygienic situation and to avoid this, now a days separate underground pipes are provided for collecting and transporting sewage and the rainwater is generally drained into the roadside gutter.

The term sewerage means the provision of drainage by sewers. The sewerage systems around the world are classified as shown in Fig. 5.9.

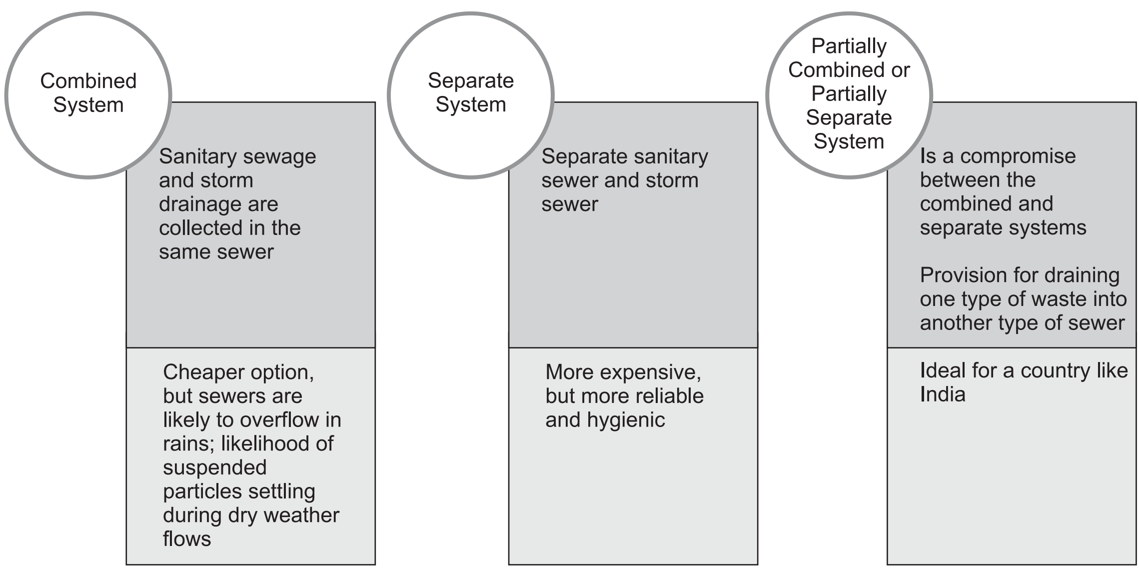
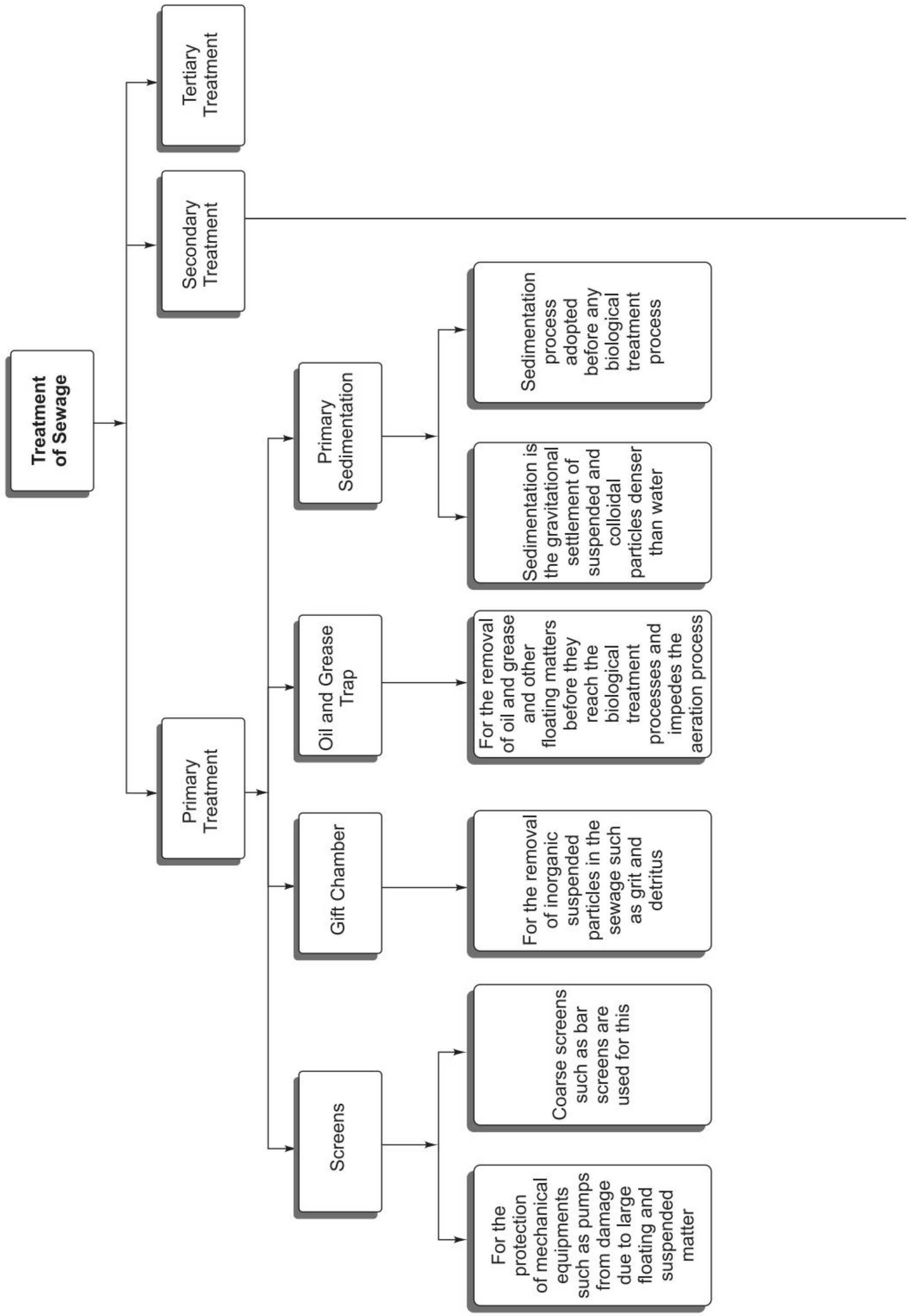


Fig. 5.9 *Sewerage Systems*

Treatment of Sewage



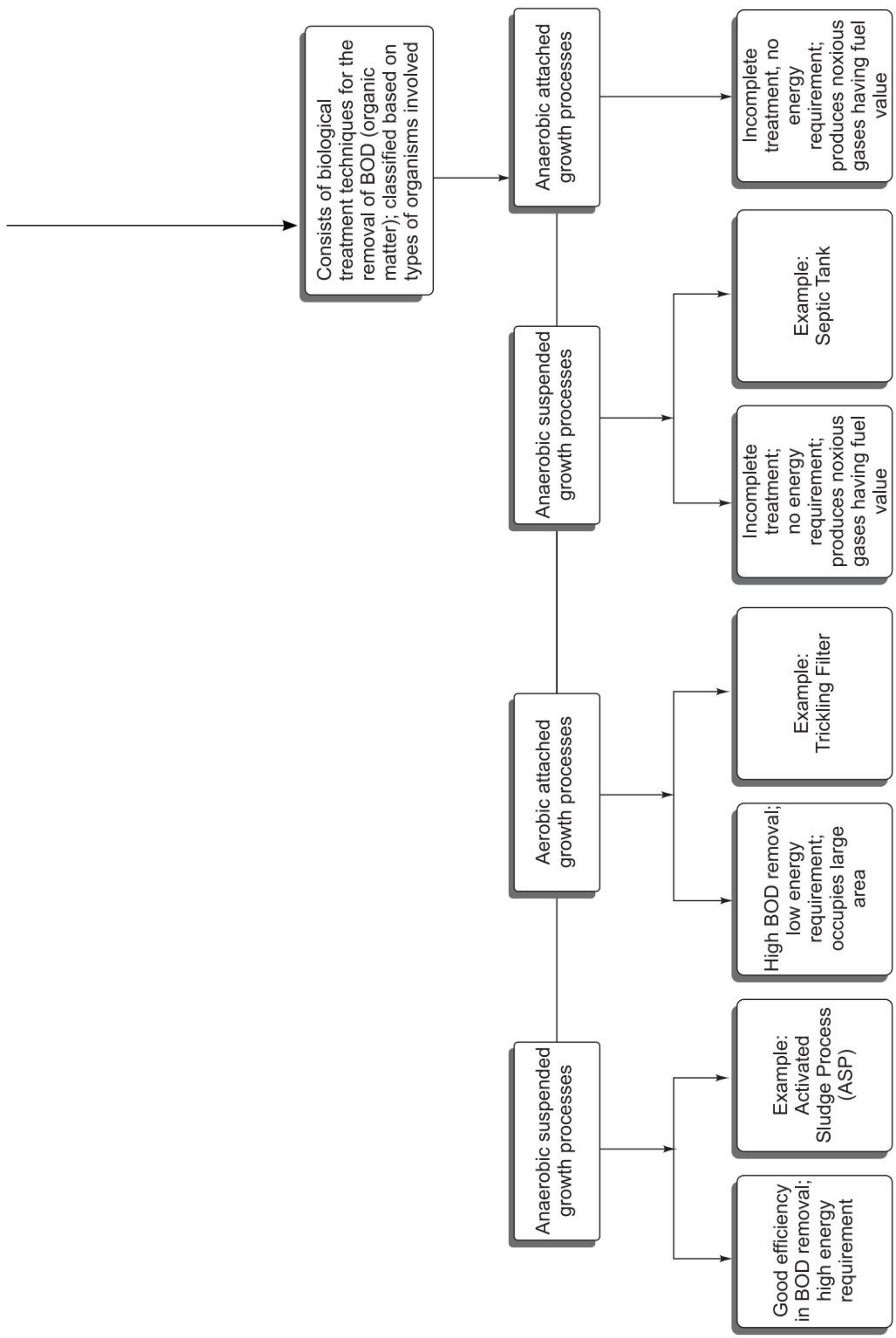


Fig. 5.10 *Classification of Methods of Sewage Treatment*

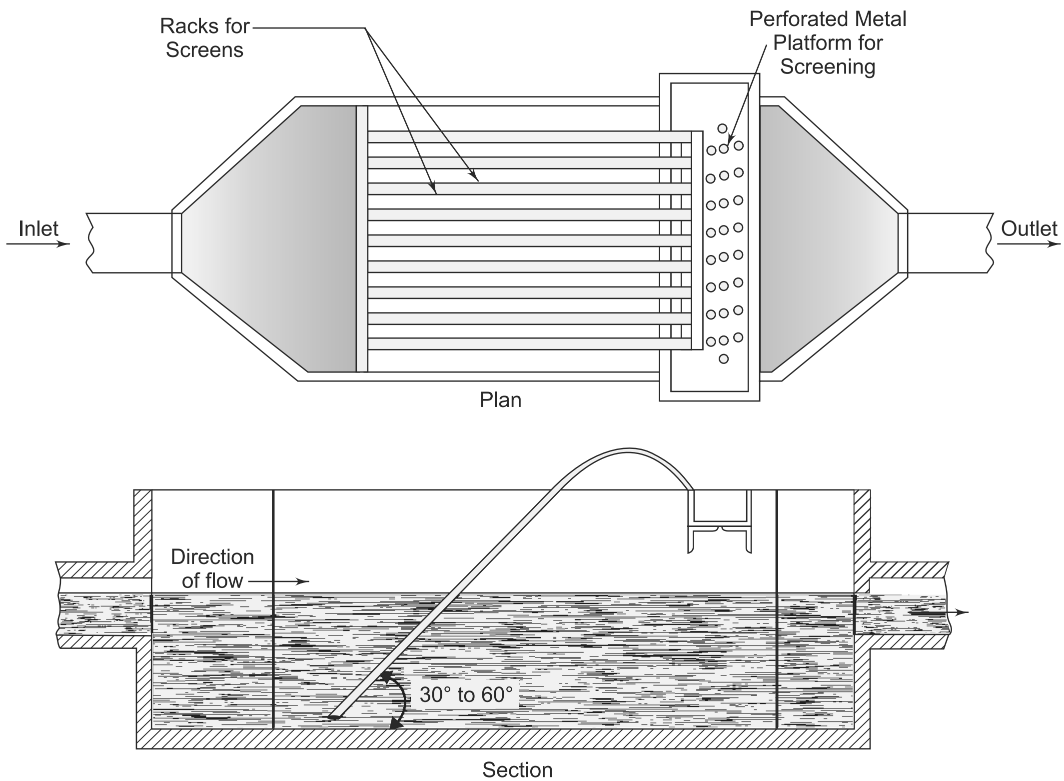


Fig. 5.11 *A Typical Bar Screen*

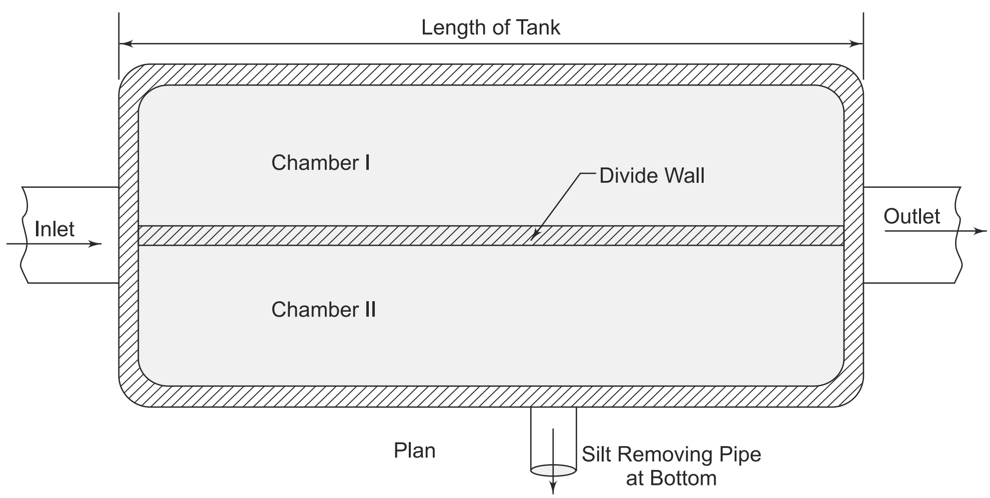


Fig. 5.12 *(Contd.)*

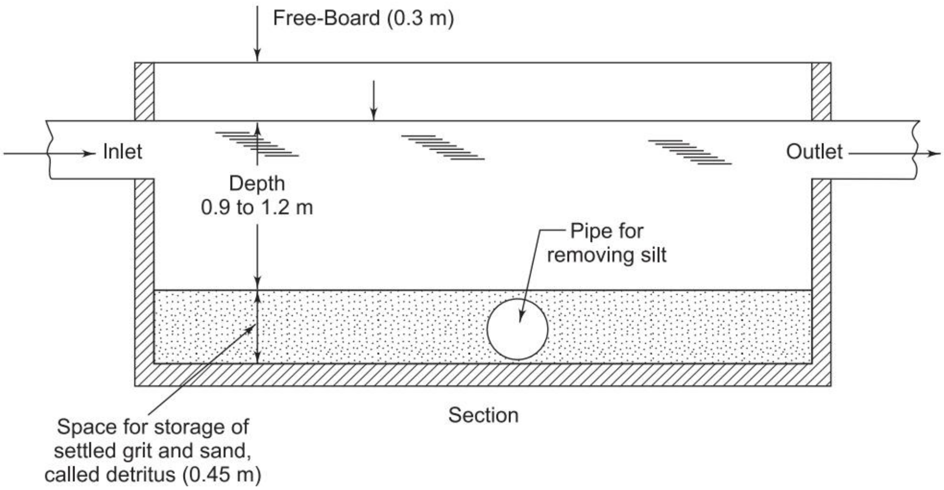


Fig. 5.12 *A Typical Grit Chamber used in Sewage Treatment*

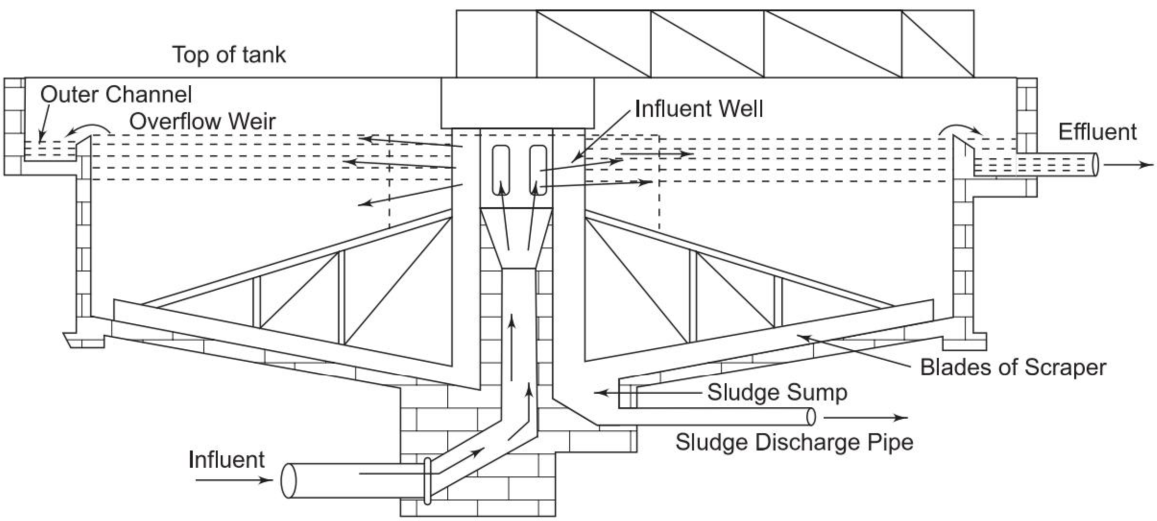


Fig. 5.13 *Circular Sedimentation Tank*

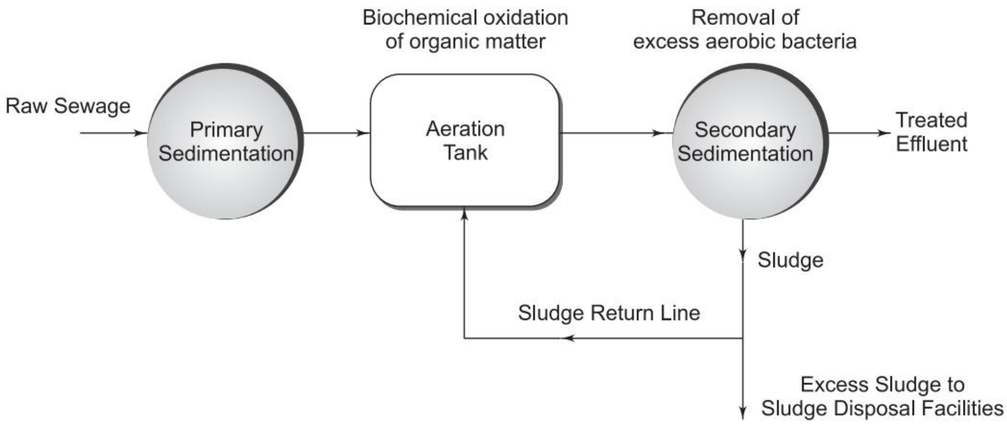
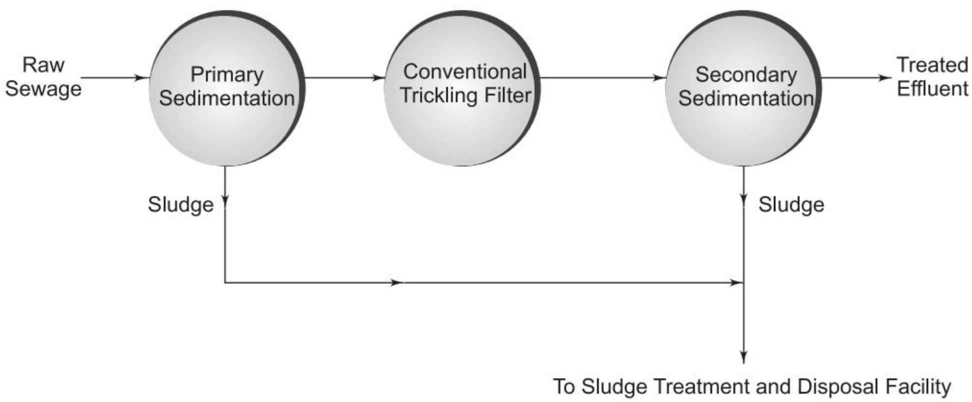
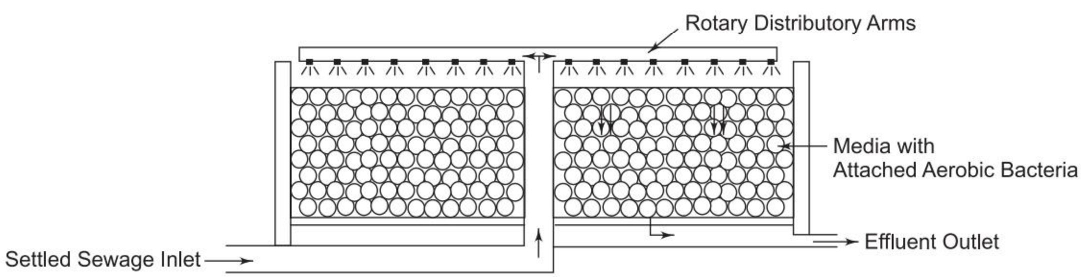


Fig. 5.14 *Conventional Activated Sludge Process*

Trickling Filter



(a) Flow Diagram of a Conventional Trickling Filter



(b) Cross-section of a Trickling Filter

Fig. 5.15 *Trickling Filter*

Septic Tank

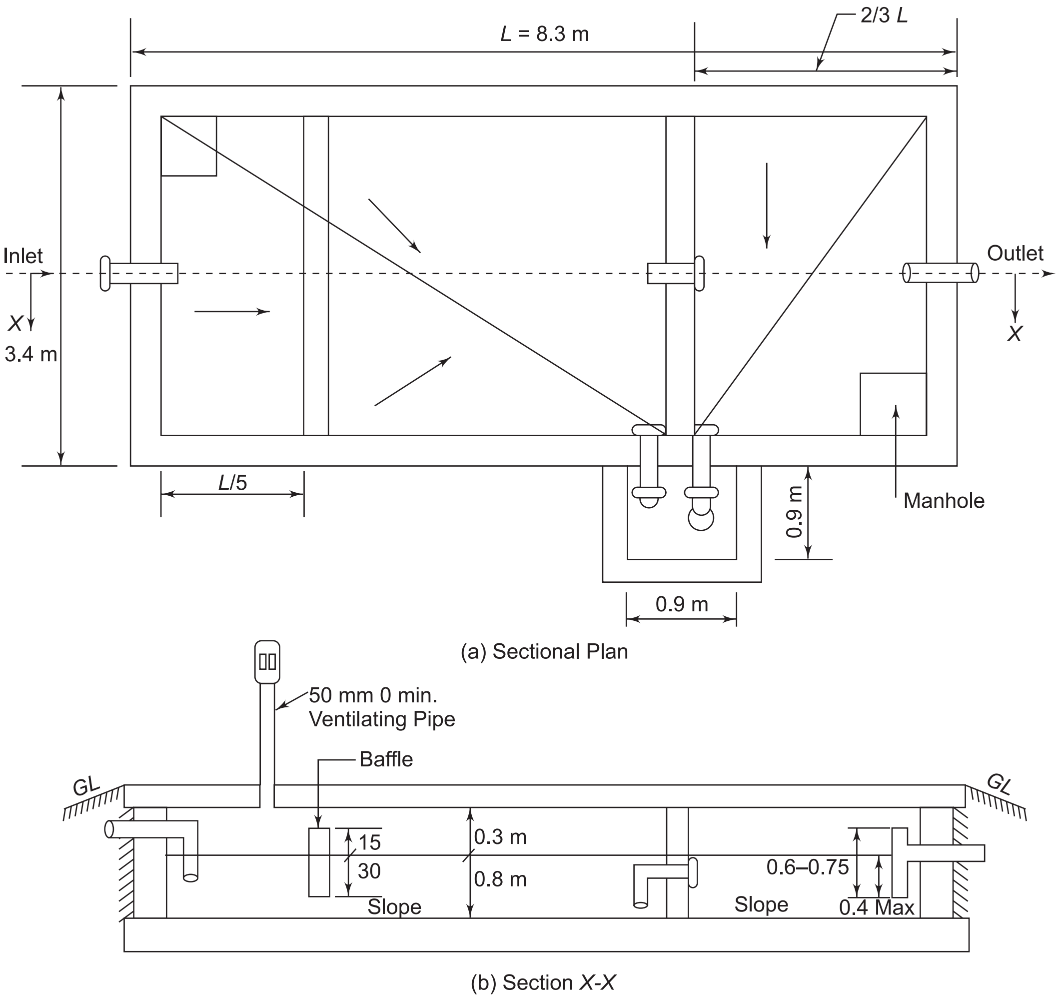


Fig. 5.16 *Septic Tank*

Oxidation Pond

Oxidation pond is a low cost natural treatment system in which the oxygen required by the bacteria for the biochemical oxidation of organic matter is provided by the atmospheric winds and algae present in the oxidation pond. Algae utilize the nutrients and carbon dioxide provided by the bacteria for photosynthesis and supplement the bacteria with oxygen, a product of photosynthesis. This symbiotic relationship between the algae and bacteria is a major feature of the oxidation pond.

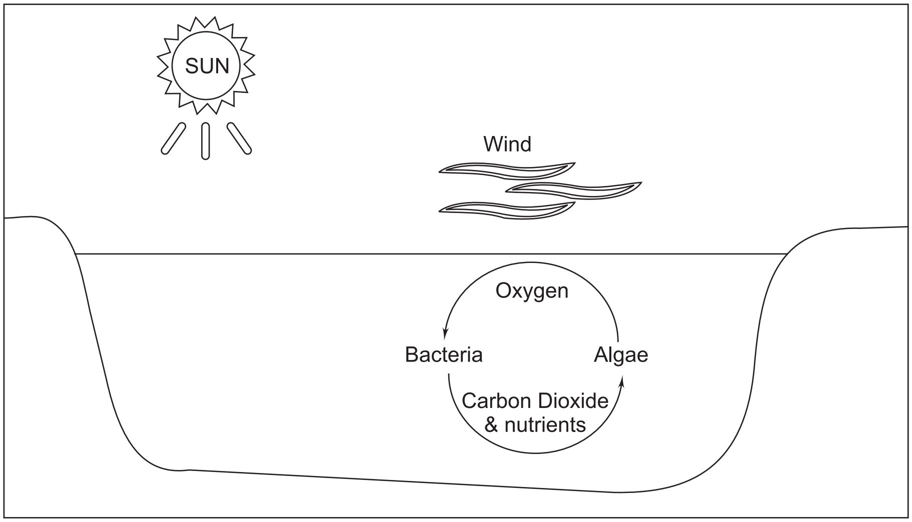


Fig. 5.17 *Symbiotic Relation between Algae and Bacteria in Oxidation Pond*

Constructed Wetlands

Constructed wetlands are engineered marshes that duplicate natural processes to cleanse water. The engineered aquatic treatment systems of constructed wetlands are classified into two basic types: Free Water Surface (FWS) and Subsurface Flow (SF) wetlands. Both types consist of a channel or a basin with some sort of barrier to prevent seepage and utilize emergent aquatic vegetation as part of the treatment system. The difference between FWS and SF is the fact that the second type uses some kind of media as a major component.

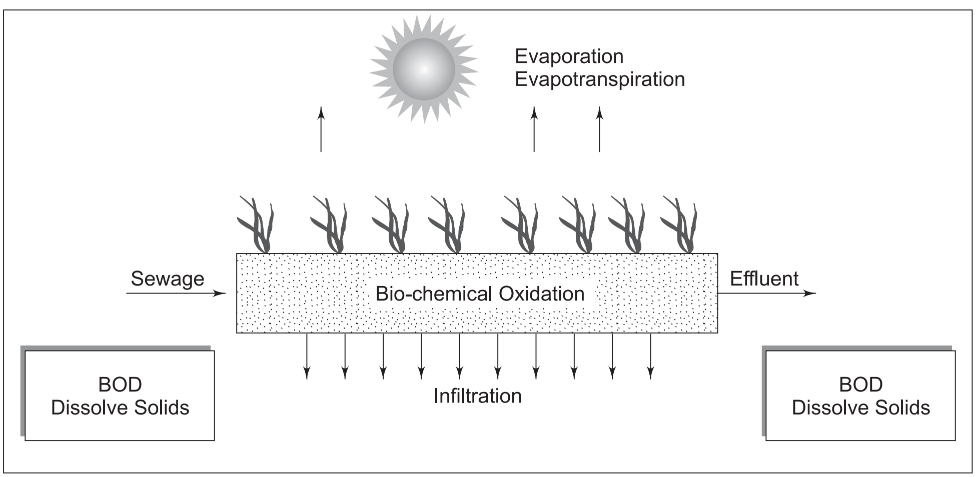


Fig. 5.18 *Constructed Wetland*

Advanced Technologies for Water and Wastewater Treatment

Filtration types The most common type of filtration in water treatment is "normal/dead end" filtration where all influent passes through a filter medium that removes contaminants to produce higher quality water. Rough screens, sand filters, multimedia filters and cartridge filters are examples of filtration products that operate this way to remove 0.1 micron particles or larger. Once the medium becomes loaded, it can be backwashed as with multi-media filters or discarded and replaced as with cartridge filters. The method of obtaining clean filtration medium is based on economic and disposal concerns. The solution is to operate membranes in the crossflow mode. By doing so, rejected contaminants are continuously carried away from the membrane surface, thereby minimizing contaminant buildup, leaving it free to reject incoming material and to allow free flow of purified water. Although membrane cleaning is periodically required, the self-cleaning nature of crossflow filtration lengthens membrane life enough to make it economically attractive. Figure 5.19 shows the working of normal/deadend and crossflow filtrations.

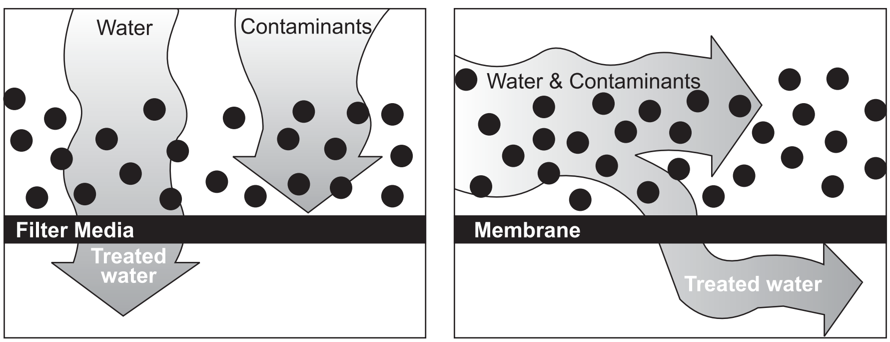


Fig. 5.19 *Normal and Crossflow Filtration*

Crossflow filtration is carried out in a machine that includes the membrane element and housings, interconnecting piping, pumps, prefilters and controls and instrumentation necessary for operation.

Although there are a few choices of medium to reject substances smaller than 0.1 micron, the most popular is the polymeric membrane, packaged into a membrane element.

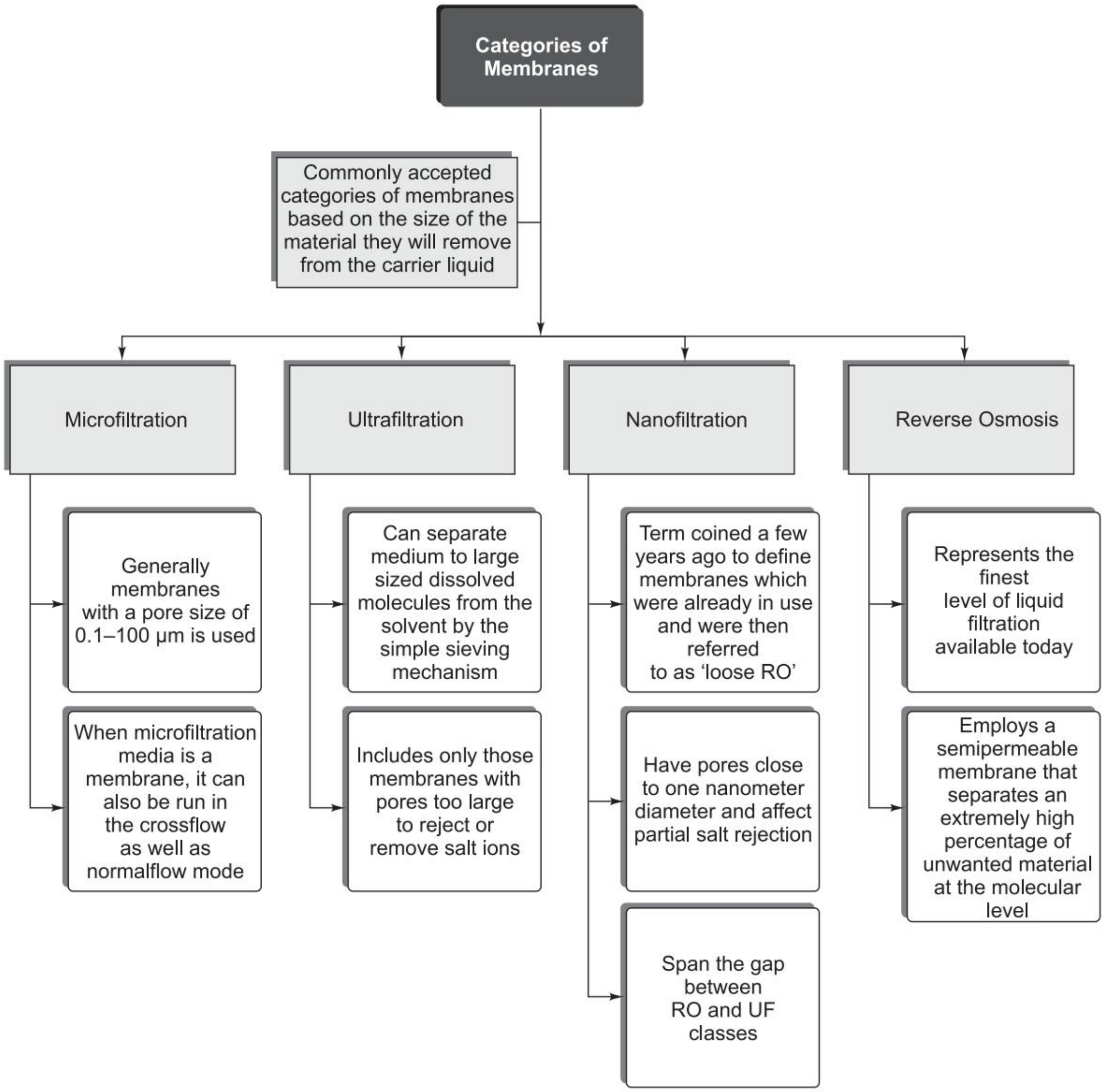


Fig. 5.20 *Classification of Membrane Filtration Systems*

Reverse Osmosis (RO)

The goal of Reverse Osmosis in water purification system is to separate the dissolved salt from the pure water. So it is necessary to reverse the natural osmotic flow by forcing the water from the salt solution through the membrane in the reverse direction. This can be accomplished by applying sufficient pressure to the salt water as it is fed into the system. This pressure creates the condition known as 'reverse osmosis'.

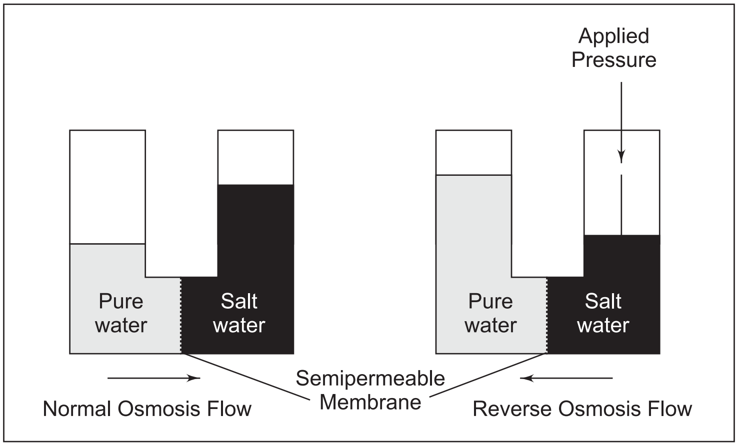


Fig. 5. 21 *Osmosis Principle*

In commercial RO systems, a semipermeable membrane is used to separate fluids of various qualities into a highly saturated concentrate (brine) and a high quality permeated fluid low in dissolved solids. The separation is accomplished by passing the fluid across the membrane at a specified pressure and velocity.

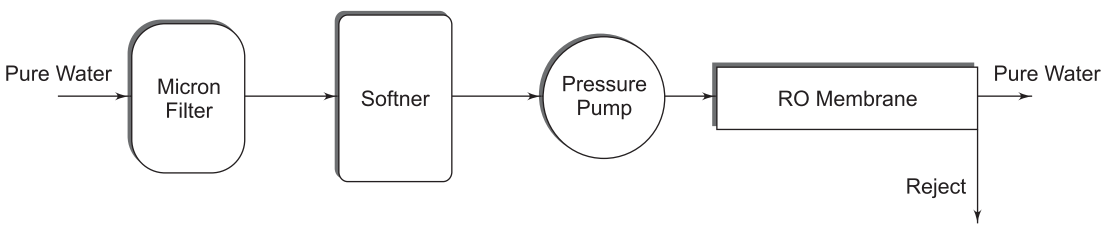


Fig. 5.22 *Flow Diagram of Typical Reverse Osmosis Plant for Water Treatment*

❑ *Semipermeable membranes* Reverse Osmosis Membranes are spiral wound filtration system using alternating semipermeable and permeable materials to process and separate the product fluid from the concentrate solution. Their filtration capabilities and application are dependent on several factors such as

- Chemical composition of the fluid to be filtered and the semipermeable material required due to this composition,
- Fluid temperature,
- Operating pressure,
- Total dissolved solids to be removed and several other minor factors.

5.3 SOIL POLLUTION

Soil is the thin layer of organic and inorganic material that covers the Earth's rocky surface. The organic portion, which is derived from the decayed remains of plants and animals, is concentrated in the dark uppermost "topsoil." The inorganic portion, which is made up of rock fragments, is formed over thousands of years by physical and chemical weathering of bedrock.

Soil contaminants are spilled onto the surface through many different activities. Most of these are the result of accidents involving the vehicles that are transporting waste material from the site at which it originated to the site at which it is to be disposed. Others involve accidents involving vehicles (automobiles, trucks and airplanes) not transporting wastes, but carrying materials, including fuel, that, when spilled, contaminate the soil.

5.3.1 Control of Soil Pollution

To help prevent soil erosion, we can limit construction in sensitive areas. In general we would need less fertilizer and fewer pesticides if we could all adopt the three R's: (Reduce, Reuse, and Recycle). This would give us less solid waste. Industrial wastes can be treated physically, chemically and biologically until they are less hazardous. As a last resort, new areas for storage may be investigated such as deep well injection and more secure landfills.

One of the techniques for treating polluted soils is bioremediation. Bioremediation is a treatment process that uses microorganisms (yeast, fungi, or bacteria) to breakdown, or degrade, hazardous substances into less toxic or nontoxic substances (carbon dioxide and water).

5.4 MARINE POLLUTION

Marine pollution can be defined as the direct or indirect introduction by humans of substances or energy into the marine environment (including estuaries), resulting in harm to living resources, hazards to human health, hindrances to marine activities including fishing, impairment of the quality of sea water and reduction of amenities.

Table 5.2 illustrates the various marine pollutants with its common sources and effects.

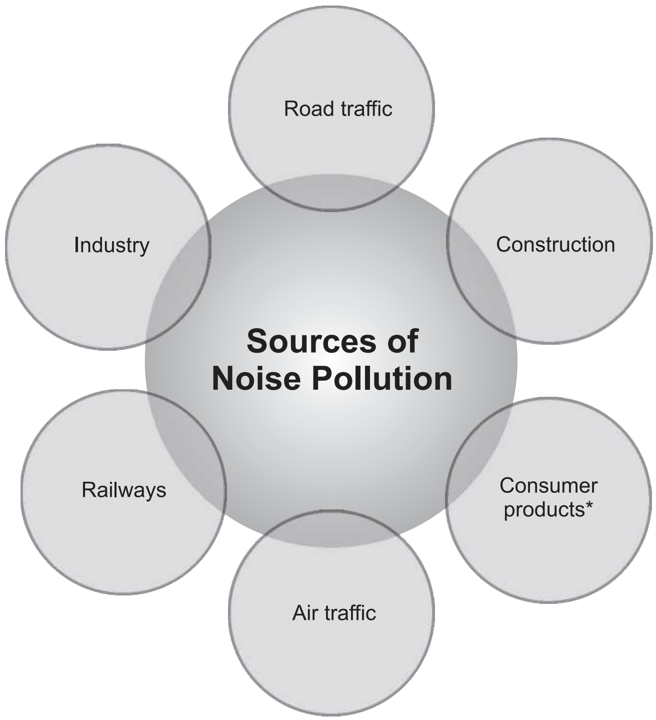
Table 5.2 *Causes and Effects of Marine Pollution*

Type	*Primary source/Cause*	*Effect*
Nutrients	Sewage, runoff from forestry, farming, and other land use. Also airborne nitrogen oxides from power plants, cars, etc.	Causes algal blooms in coastal waters. Decomposing algae depletes water of oxygen, killing other marine life. Can cause algal blooms releasing toxins that can kill fish and poison people.
Sediments	Erosion from mining, forestry, farming, and other landuse; coastal dredging and mining.	Cloudy water; impede photosynthesis below surface waters. Clog gills of fish. Smother and bury coastal ecosystems. Carry toxins and excess nutrients.
Pathogens	Sewage, livestock.	Contaminate coastal swimming areas and seafood, spreading cholera, typhoid and other diseases.
Alien Species	Several thousands per day transported in ballast water; also spread through canals linking bodies of water and fishery enhancement projects.	Outcompete native species and reduce biological diversity. Introduce new marine diseases. Associated with increased incidence of red tides and other algal blooms. Problem in major ports.
Persistent Toxins (PCBs, Heavy metals, DDT, etc.)	Industrial discharge; wastewater discharge from cities; pesticides from farms, forests, home use, etc.; seepage from landfills.	Poison or cause disease in coastal marine life, especially near major cities or industry. Contaminate seafood. Fat-soluble toxins that bio-magnify in predators, can cause disease and reproductive failure.
Oil	From cars, heavy machinery, industry, other land-based sources; oil tanker operations and other shipping; accidents at sea; also offshore oil drilling and natural seepage.	Low level contamination can kill larvae and cause disease in marine life. Oil slicks kill marine life, especially in coastal habitats. Tar balls from coagulated oil litter beaches and coastal habitat.
Plastics	Fishing nets; cargo and cruise ships; beach litter; wastes from plastics industry and landfills.	Discarded fishing gear continues to catch fish. Other plastic debris entangles marine life or is mistaken for food. Plastics litter beaches and coasts and may persist for 200 to 400 years.
Radioactive Substances	Discarded nuclear submarine and military waste; atmospheric fallout and industrial wastes.	Hotspots of radioactivity. Can enter food chain and cause disease in marine life. Concentrate in top are predators and shellfish, which are eaten by people.
Thermal	Cooling water from power plants and industrial sites.	Kill corals and other temperature sensitive sedentary species. Displace other marine life.
Noise	Supertankers, other large vessels and machinery.	Can be heard thousands of kilometers away under water. May stress and disrupt marine life.

5.5 NOISE POLLUTION

Noise is an unwanted sound. Noise pollution can be defined as unwanted or offensive sounds that unreasonably intrude into our daily activities.

5.5.1 Sources of Noise



* home appliances, musical instruments, lawn mowers, go carts, motorcycles, air conditioners, etc.

Fig. 5.23 *Sources of Noise Pollution*

5.5.2 Measurement of Noise

Noise intensity is measured in decibel units. The decibel scale is logarithmic; each 10-decibel increase represents a tenfold increase in noise intensity.

5.5.3 Effects of Noise

Subjected to 45 decibels of noise, the average person cannot sleep. At 120 decibels the ear registers pain, but hearing damage begins at a much lower level, about 85 decibels.

The duration of the exposure is also important. Apart from hearing loss, noise can cause lack of sleep, irritability, heartburn, indigestion, ulcers, high blood pressure, and possibly heart disease.

5.5.4 Noise Pollution Control

The Source Path Receiver Concept

Noise pollution can be controlled by either reducing the noise at the source or by preventing its transmission or by protecting the receiver.

5.6 THERMAL POLLUTION

Thermal pollution increases water temperature, causing a change (lowering) of dissolved oxygen levels. This disrupts the body of water's ecological balance, resulting in the suffocation of some plant and animal species while encouraging the overgrowth of others.

Human activities can introduce thermal pollution into streams in several ways such as the following.

- Industries and power plants may use water to cool machinery and then discharge the warmed water into a stream.
- Water temperature rises when trees and tall vegetation providing shades are cut down.
- Soil erosion caused by construction, removal of stream side vegetation, poor farming practices, overgrazing and recreation increases the amount of suspended solids in the water.
- Thermal pollution can also occur through earthquakes.

The effects of thermal pollution are of two types.

1. ***Thermal shock*** The sudden change in temperature due to hot wastewater can be of harm to fish and other aquatic animals that have been used to a particular level of water temperature; this invariably can cause fish to migrate to a more suitable environment.
2. ***Thermal enrichment*** This is when heated water from power plants may be used for irrigation purposes to extend plant growing seasons, speed up the growth of fish and other aquatic animals for commercial purposes. However, it has been noted that the harmful effects of thermal pollution outweigh the benefits.

5.7 SOLID WASTE MANAGEMENT

5.7.1 Solid (Non-hazardous) Waste

Examples of such waste include domestic trash and garbage, other refuse such as metal scrap, and empty containers; and other discarded materials from industrial operations, such as boiler slag and fly-ash.

5.7.2 Refuse

Refuse means all decomposing and non-decomposing combustible and non-combustible solid wastes including, but not limited to, garbage, ashes, paper, wrappings, cigarette and cigar butts, cardboard, cans, wood scraps, loose glass in any form, bedding, metal, household items, crockery, plastic, industrial wastes, prunings, grass clippings, weeds, leaves, general yard and garden wastes, cut or fallen trees and shrubs.

5.7.3 Municipal Solid Waste (MSW)

MSW is commonly known as trash or garbage and consists of everyday items such as product packaging, grass cropping, furniture, clothing, bottles, food scraps, newspapers, appliances, paint, and batteries.

5.7.4 Hazardous Waste

Hazardous waste is solid waste that has hazardous waste characteristics or is a listed hazardous waste, and is not otherwise excluded from regulation.

5.7.5 Illegal Dumping

Illegal dumping is the disposal of solid and hazardous waste in a non-permitted area. Illegal dumping is also known as "open dumping", "fly dumping", or "midnight dumping".

5.7.6 MSW Management Practices

The hierarchy of waste management is as follows and is represented diagrammatically in Fig. 5.24.

- Avoid
- Minimize
- Recycle
- Treat
- Dispose

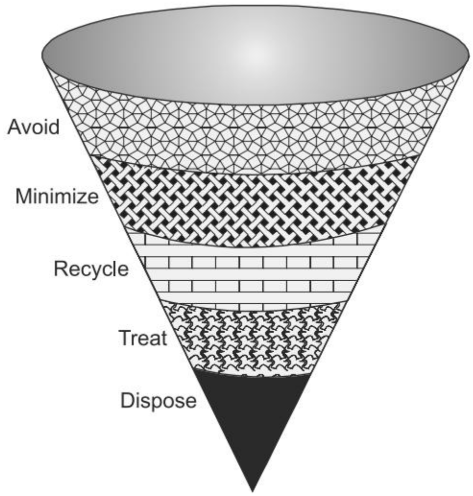


Fig. 5.24 *Waste Management Hierarchy*

There are several MSW management practices, such as source reduction, recycling, composting and prevention or diversion of materials from the waste stream.

A few typical MSW processing flow diagrams are shown in Figs. 5.25, 5.26 and 5.27.

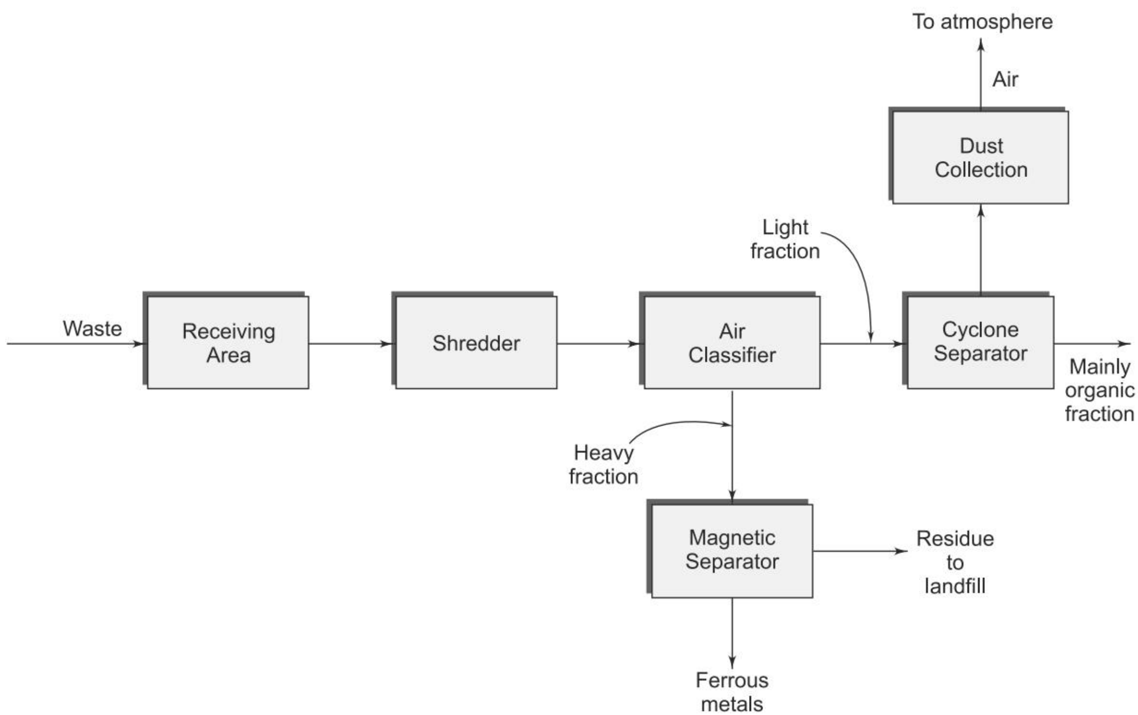


Fig. 5.25 *Separation of MSW Components*

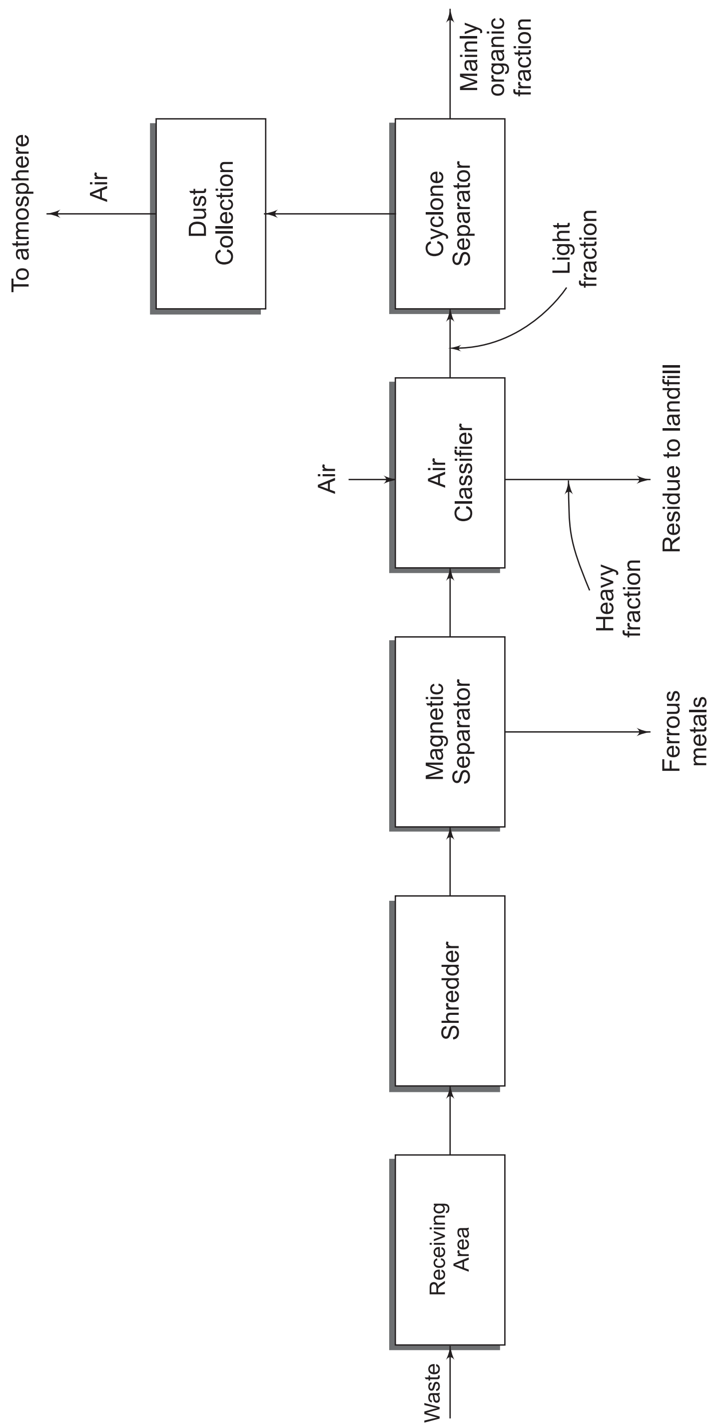


Fig. 5.26 *Separation of MSW Components*

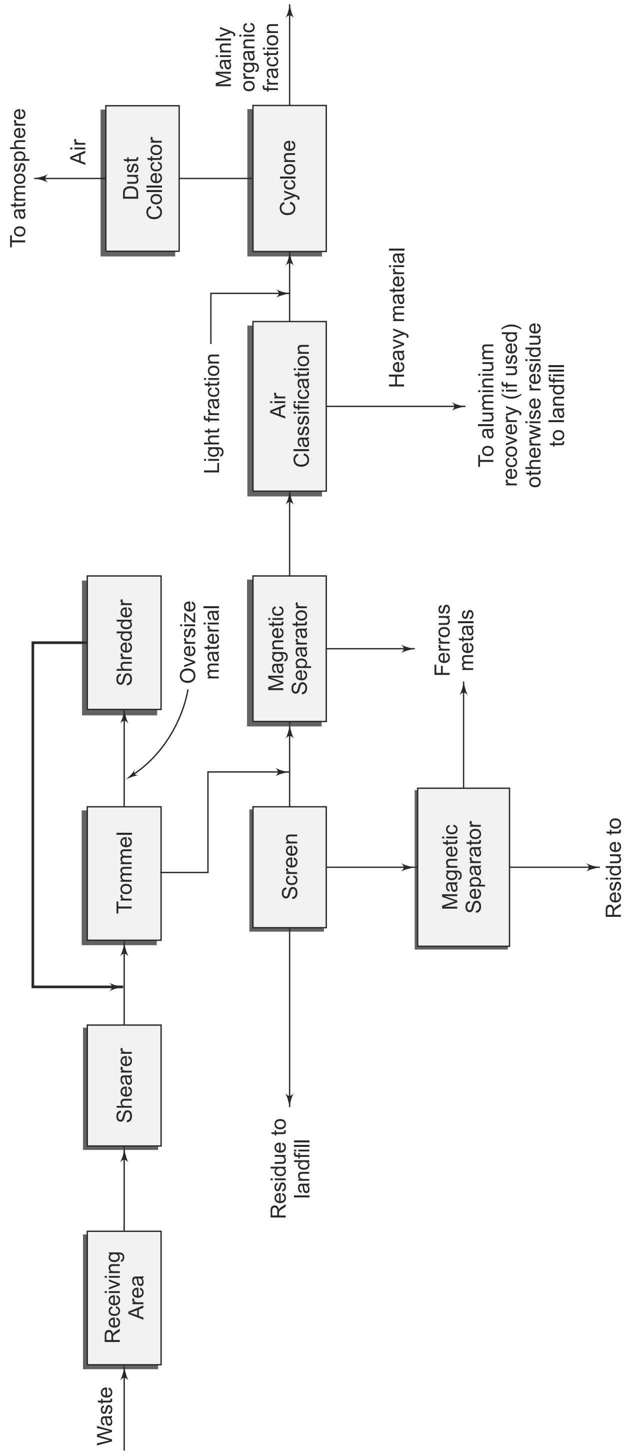


Fig. 5.27 *MSW Processing Plant Flow Diagram*

Figure 5.28 illustrates the flow diagram of a plant in which the organic fraction from MSW is used for the production of Refuse Derived Fuel (RDF) in powder and pellet form. The RDF can be used as a partial replacement for coal in many instances.

Figure 5.29 is the flow diagram of an MSW processing plant incorporating material and energy recovery. Here materials of considerable fuel value are dried and burned in the boiler to run a steam turbine for the production of electricity.

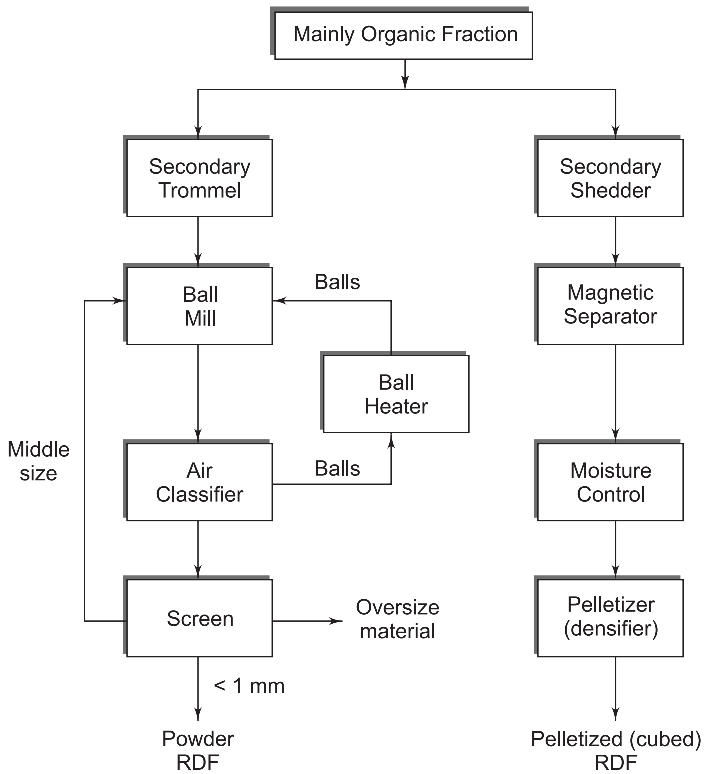


Fig. 5.28 *MSW Organic Fraction Processing for Reuse*

When a solid waste contains large proportion of organic contents such as vegetables, it is possible to anaerobically digest the organic matter and get biogas. This biogas could be used for the production of electricity. Figure 5.30 shows the flow diagram of an MSW processing unit incorporating an anaerobic digester for energy recovery.

Figure 5.31 shows the various options currently available for the major components of MSW.

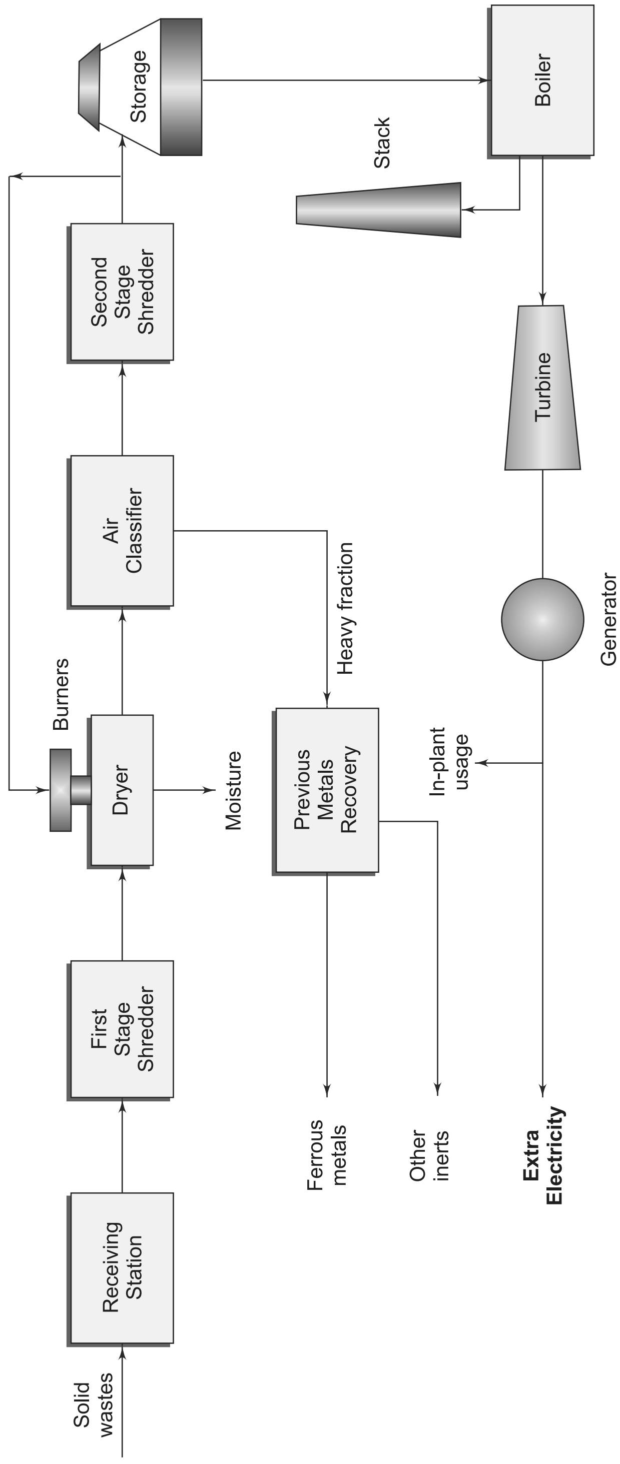


Fig. 5.29 *Power Generation from MSW Combustible Components*

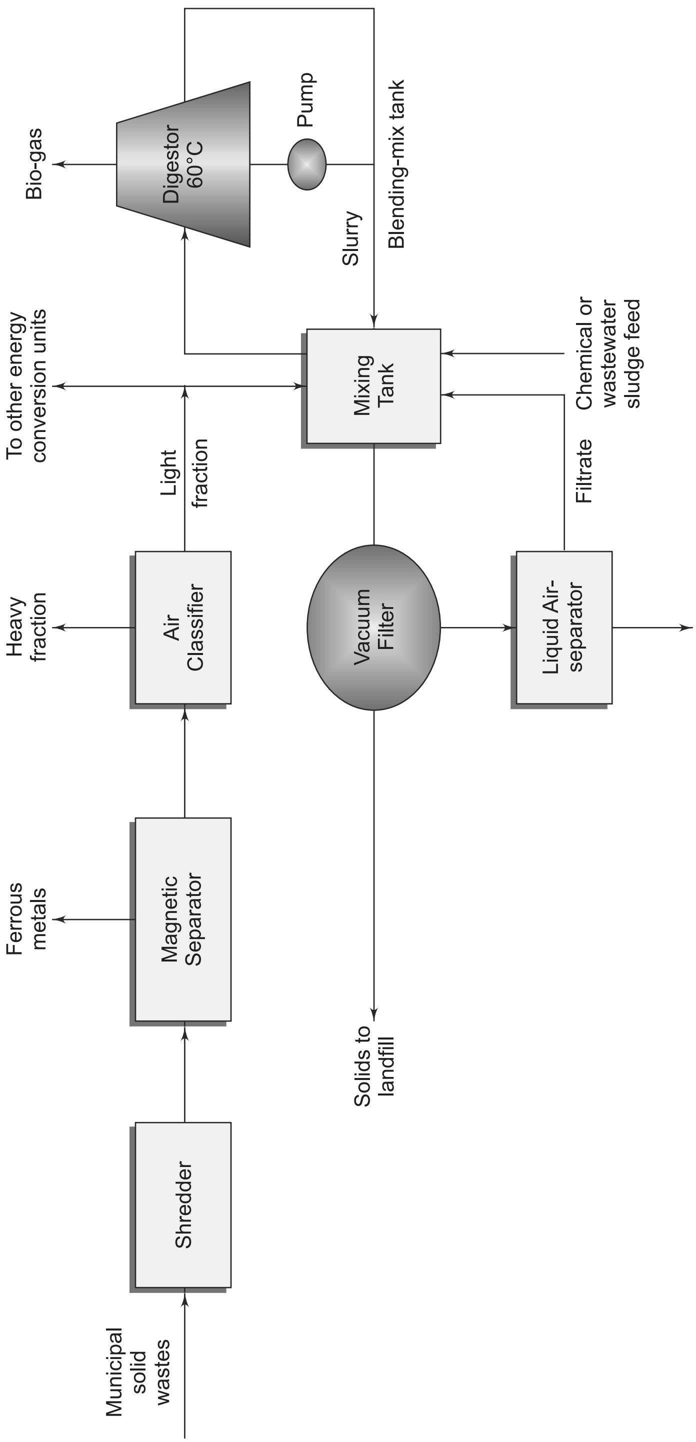


Fig. 5.30 *Energy and Material from MSW through Biogasification of Organic Components*

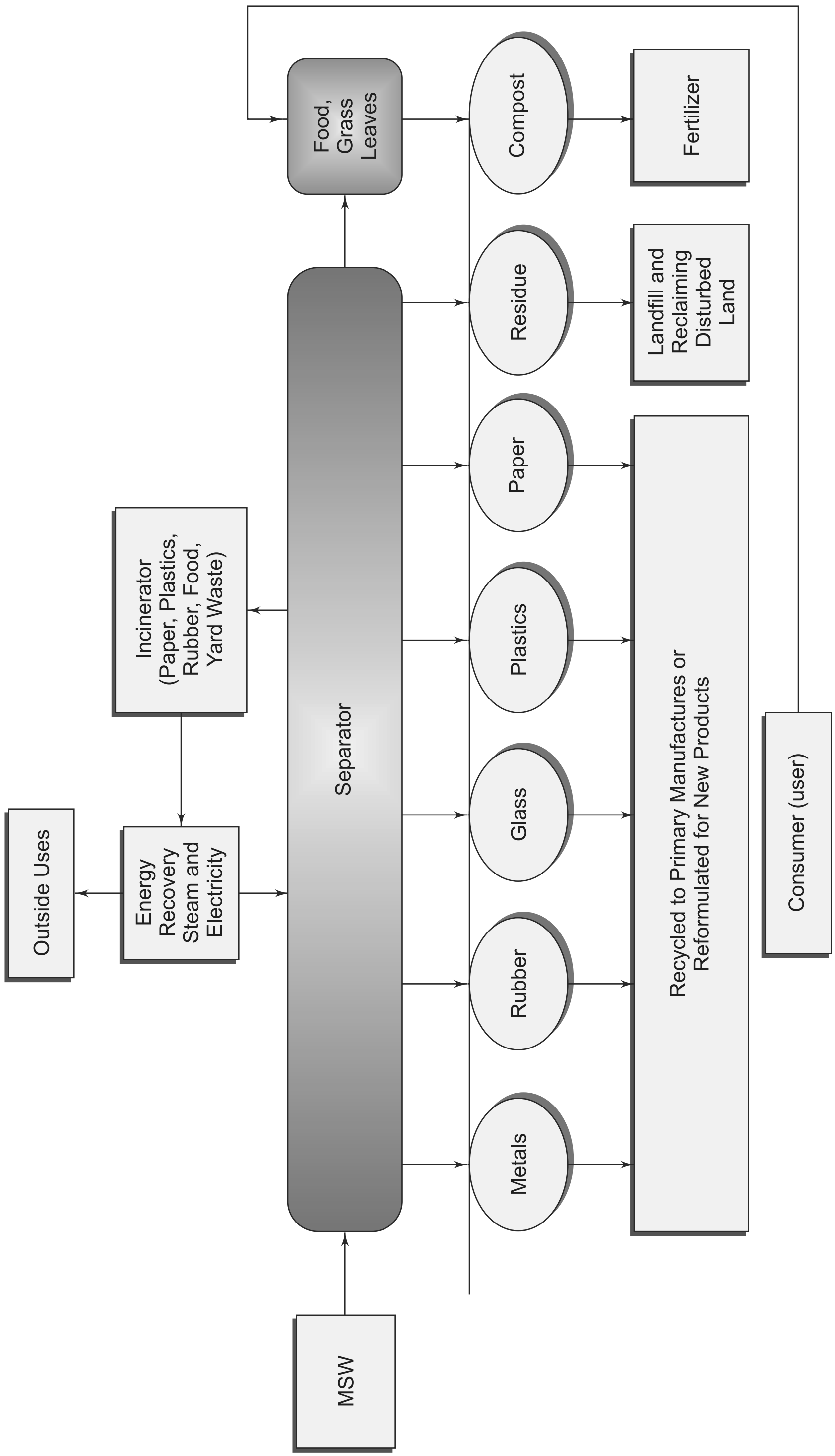


Fig. 5.31 *Recycling and Disposal Options for Various Components of MSW*

5.7.7 Source Reduction

Source reduction involves altering the design, manufacture, or use of products and materials to reduce the amount of waste thrown away. Practices such as backyard composting, two-sided copying of paper, and transport packaging reduction by industry have yielded substantial benefits through source reduction.

5.7.8 Recycling

Recycling diverts items, such as paper, glass, plastic, and metals, from the wastestream. These materials are sorted, collected, and processed and then manufactured, sold, and bought as new products. Typical materials that can be recycled include batteries, paper and paperboard. These materials may be recycled through curbside programmes, drop-off centers, buy-back programmes or deposit systems.

5.7.9 Composting

Composting is the biological decomposition of organic constituents of MSW such as leaves, grass, and food scraps, by microorganisms under controlled conditions.

Carbon	Nitrogen	Moisture	Oxygen and Temperature
■ Serves as an energy source for microorganisms ■ A small fraction of carbon is incorporated in their cells	■ Is critical for microbial population growth as it is a constituent of protein which forms over 50% of dry bacterial cell mass	■ Most decomposition occurs in thin liquid films on the surfaces of particles ■ Moisture management requires a balance between two functions – microbial activity and oxygen supply	■ Both fluctuate in response to microbial activity, which consumes oxygen and generates heat ■ Also linked by aeration - replenishes oxygen as it is depleted and carries away excess heat ■ Heat is a by-product of decomposition and is important in raising and maintaining temperatures for efficient decomposition ■ Inadequate oxygen levels lead to the growth of anaerobic microorganisms, which can produce odorous compounds

Fig. 5.32 *Elements of the Composting Process*

5.7.10 Classification of Composting Based on Oxygen Use

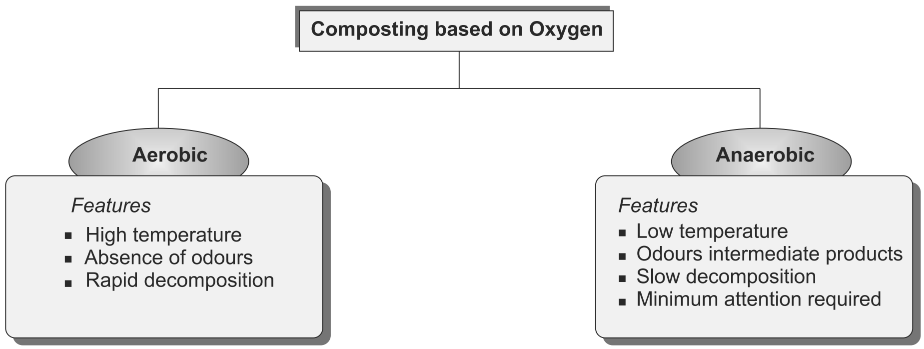


Fig. 5.33 *Classification of Composting Based Oxygen Use*

5.7.11 Vermicomposting

Although not significant in terms of waste diversion, vermicomposting is being used in some places. This method of composting uses a container of food scraps and a special kind of earthworm. Over time, the food is replaced with worm droppings, a rich brown matter that serves as an excellent natural plant food.

5.7.12 Landfills

Landfills are engineered areas where waste is placed into the land. Landfills usually have liner systems and other safeguards to prevent groundwater contamination. Figure 5.34 shows the cross sections of typical landfills for solid waste disposal.

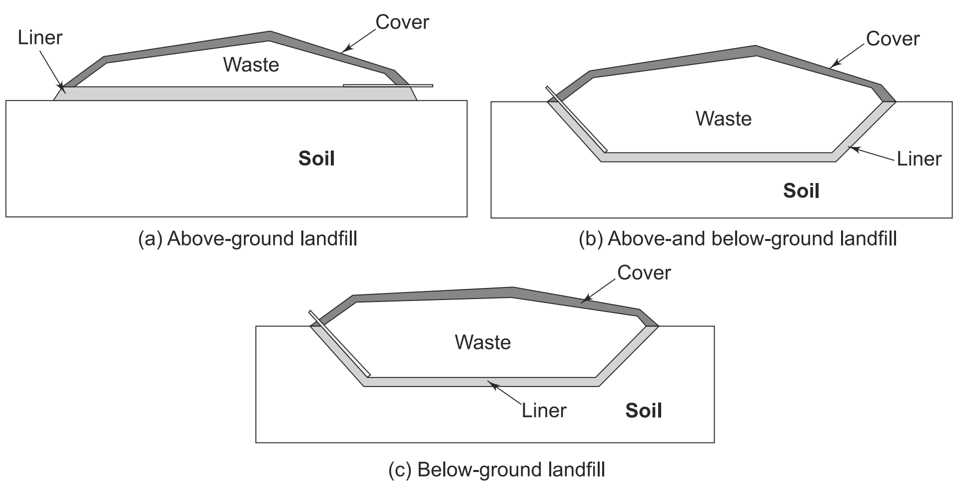


Fig. 5.34 *Cross-section of Landfills for Solid Waste Disposal*

5.7.13 Combustion/Incineration

Incineration is another MSW disposal practice that helps to reduce the amount of landfill space needed. Combustion facilities burn MSW at a high temperature, reducing waste volume and generating electricity.

5.7.14 Disposal and Recycle Options

Table 5.3 shows the disposal and recycle options for various items in different communities.

Table 5.3 *Disposal Options for Various Waste Components*

Item	*For a high-waste throwaway system*	*For a moderate-waste resource recovery and recycling system*	*For a low-waste sustainable-earth system*
Glass bottles	Dump or bury	■ Grind and remelt; ■ Remanufacture; ■ Convert to building materials	■ Ban all non-returnable bottles ■ Reuse bottles
Bimetallic "tin" cans	Dump or bury	Sort, remelt	■ Limit or ban production ■ Use returnable bottles
Aluminium cans	Dump or bury	Sort, remelt	■ Limit or ban production ■ Use returnable bottles
Cars	Dump	Sort, remelt	■ Tax cars lasting less than 15 years and getting less than 17 km/L
Metal objects	Dump or bury	Sort, remelt	■ Tax items lasting less than 10 years
Tyres	Dump, burn, or bury	Grind and revulcanize or use in road construction; incinerate to generate heat and electricity	■ Recap usable tyres ■ Tax or ban all tyres not usable for at least 20,000 km
Paper	Dump, burn, or bury	Incinerate to generate heat	■ Compost or recycle ■ Tax all throwaway items ■ Eliminate over packing
Plastics	Dump, burn, or bury	Incinerate to generate heat or electricity	■ Limit production ■ Use returnable glass bottles instead of plastic containers ■ Tax throwaway items and packaging
Yard wastes	Dump, burn, or bury	Incinerate to generate heat or electricity	■ Compost ■ Return to soil as fertilizer ■ Use as animal feed

5.7.15 Prohibited Wastes

The following is a list of prohibited wastes in the conventional management of municipal solid waste.

- Hazardous waste
- Radioactive waste
- Industrial process waste
- Infectious (biomedical) waste
- Asbestos or sludge
- Characteristic hazardous waste
- Pesticides or herbicides
- Automotive batteries
- PCB's or bulk liquids
- Motor oil

5.8 HAZARDOUS WASTE MANAGEMENT

5.8.1 Hazardous Waste

A hazardous waste is any waste or combination of wastes that poses a substantial danger, now or in future, to human plant or animal life and which therefore cannot be handled or disposed of without special precaution. The following is a list of types of hazardous wastes:

- Specific type of wastes from nonspecific sources
- Specific type of wastes from specific sources
- Specific substances identified as acute hazardous waste
- Specific substances identified as hazardous wastes
- Characteristic wastes which exhibit any of the following properties:
  - Ignitability–Easily inflammable with flash point below 60°C
  - Corrosivity–pH less than 2 or more than 12.5
  - Reactivity–Unstable or undergoes rapid or violent reaction with water or other materials and releases toxic gases
  - Toxicity–Toxic to human beings

5.8.2 General Hazardous Waste Management Strategies

The following is a list of general strategies for the management of hazardous wastes:

- Minimize
- Stimulate waste exchange
- Recycle
- Detoxify
- Reduce the volume
- Incinerate
- Stabilize/solidify
- Dispose in special landfills

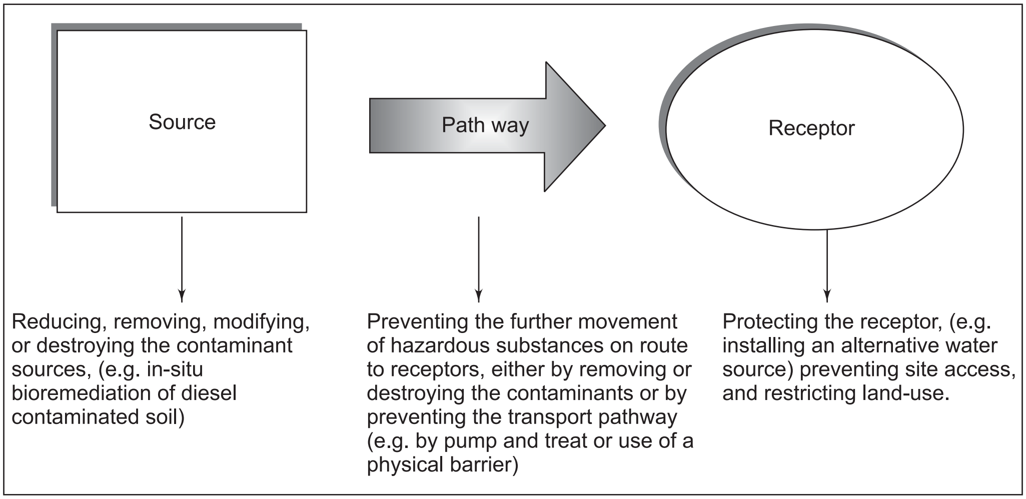


Fig. 5.35 *Risk Management and Risk Reduction from Hazardous Waste using the Source-Path-Receiver Concept*

5.8.3 Treatment Technologies for Hazardous Wastes

Listed below are the treatment technologies for hazardous wastes:

- Biological treatment
- Neutralisation
- Precipitation
- Carbon adsorption
- Ion exchange
- Chemical treatment
- Oxidation
- Reduction
- Distillation
- Electrodialysis

- Reverse osmosis
- Solvent extraction
- Incineration

5.8.4 Land Disposal Methods for Hazardous Wastes

The most common land disposal methods for hazardous wastes are as follows:

- Deep well injection
- Land treatment
- Secure landfill

5.8.5 Radioactive Wastes

Radioactive waste is the material resulting from the manufacture or use of substances containing at least one element of unstable atomic structure. The sources of radioactive waste includes nuclear power plants, medical facilities and research institutions.

High-level Radioactive Waste Management

- Store indefinitely
- Reprocess
- Dispose of by burial or isolation

Low-level Radioactive Waste Management

- Waste minimization
- Volume reduction by compression
- Volume reduction by incineration
- Containment

5.8.6 Not in My Backyard Principle (NIMBY)

Whenever a community is faced with the proposal of a hazardous waste management facility being located in its midst, the response is usually, "Not in my backyard!" This response has been known as the NIMBY principle. The NIMBY principle prevents the construction of new environmentally sound disposal sites, and forces hazardous waste facilities to be built upon the existing, already contaminated sites. Often the geology of these locations is less favourable for containment than new sites would be. But we are forced to stick to them just because they already are in existence.

5.8.7 Guidelines for Handling Household Hazardous Chemicals

- Inventory all products in your home
- Read the product labels
- Buy only what you need
- Keep out of reach of children
- Don't store chemicals with food
- Don't store flammable liquids or gases in the home
- Recycle
- Use non-hazardous alternative products whenever possible
- Dispose of properly
- Keep hazardous products in original containers
- Never put hazardous wastes in household garbage
- Never reuse pesticide containers

5.8.8 Disposal Methods for Household Hazardous Wastes

1. Automotive Products

❑ *Waste oil/gasoline*

- Drain used oil into a plastic leak-proof container with a tight-fitting lid
- Take to a service station or oil change business that accepts it for recycling or to the Household Hazardous Waste Facility
- Discard empty oil bottles in the trash with the lid on
- Do not dump used oil on ground, into street drains or down the sink. One liter of used oil can contaminate one million liters of water

❑ *Car batteries* Exchange for a new battery or take to a service station/recycling center or the Household Hazardous Waste Facility for recycling.

2. Paints and Related Products

❑ *Paint and paint removers*

- Check into non-toxic alternatives for some of these products
- Take to the Household Hazardous Waste Facility for collection

- ❍ Use adequate ventillation and exercise caution with these products
- ❍ Never put paint brushes in mouth

❑ *Paint*

- ❍ Paint out small amounts on newspaper to empty cans. Recycle empty and dry paint cans (no lids) with scrap metal
- ❍ Alternative–Use latex and water-based paints which do not require hazardous cleanup materials, or buy non-toxic paints when available

❑ *Paint solvents and thinner*

- ❍ Avoid using oil-based paints and other products that require solvents or thinner for cleanup
- ❍ In a closed jar, allow sludge to settle to bottom, then pour off and re-use the clear liquid on top. Soak up sludge with an absorbent allow drying in a well-ventilated area away from children and pets, and then discard in the trash
- ❍ Take unused portion to Household Hazardous Waste treatment facility

5.8.9 Chemical Waste

Chemical wastes include solvents, acids, alkalis, organic and inorganic chemicals, poisons and cytotoxics. Incompatible chemical wastes must be segregated.

5.8.10 Chemical Incompatibilities

Some chemicals are not compatible with others. Chemical reactions are fairly common in waste collection containers. Incompatible materials may burst into flames immediately or hours after mixing; emit noxious or toxic gases; or simply bubble and flow out of the container. As a rule, do not mix or store the following chemical classes together:

- ❍ Acids and alkalies
- ❍ Bleaches
- ❍ Oxidizing agents
- ❍ Reducing agents
- ❍ Solvents and flammables

5.8.11 Biomedical Waste

This type of waste includes surgical dressings, cultures, biological tissues, needles and other sharps. In general, clinical and biological waste must be decontaminated or sterilized before leaving the hospital. Sharps must be segregated from other types of clinical and biological waste by collection in an approved sharps container.

5.8.12 Infectious Waste

The term **infectious waste** includes: biohazardous waste, biological waste, medical waste, hospital waste, medical hazardous waste, infective waste, microbiological waste, pathological waste, and blood bag waste.

5.8.13 Central Pollution Control Board Standards

In India the central pollution control board (CPCB) has laid out detailed standards and guidelines for the operating parameters of incinerators, autoclavier, microwave systems and deep burial for the infectious waste.

5.8.14 Computer and Electronic Scrap Recycling

The Problem of E-waste

Computer manufacturing releases dioxin (a carcinogen and hormone disruptor), halogens and chlorofluorocarbons (CFCs)—(ozone depleting and global warming gases) lead, mercury, and other pollutants. Some manufacturers are producing equipment without some of these toxins, with recycled-content glass and plastics, or with easily removable parts to facilitate recycling.

Junk IT hardware is also known as electronic waste or e-waste. Other electronic equipment such as mobile phones, stereos and microwaves are also e-waste. The disposal of e-waste is a huge issue globally. The problem is difficult to solve because e-waste is composed of thousands of different substances including lead, beryllium, mercury, cadmium, and brominated flame retardants. These ingredients are not easy to separate for reuse or recycling. Many of the component parts of e-waste are so hazardous that they pose both—occupational and environmental threats.

Solution for E-waste

From 2004, the European Union Waste Electrical and Electronic Equipment (WEEE) Directive is tackling the increasing waste streams of electrical and electronic equipment by requiring manufacturers to take back equipment for recycling.

5.8.15 Technology for Processing Printed Circuit Boards (PCB)

Recycling Printed Circuit Boards

Around 60 million PCBs are produced around the world each year. Each circuit board has a metal content of up to 30% by weight. The metals present in the majority of cases are gold, silver, copper, tin and lead. Many of the processes used to recover non-precious metals are based on mechanical, pyrometallurgical and hydrometallurgical techniques, in which the value of the electronic component is totally lost and maximum metal recovery is not possible. A newly developed integrated approach at Cambridge University enables the components to be separated and resold, the solder leached and re-deposited as a solder alloy and the shredded boards to be reused as a binder in aggregate use.

5.9 POLLUTION PREVENTION

Pollution prevention is source reduction and other practices that reduce or eliminate the creation of pollutants through the increased efficiency in the use of raw materials, energy, water or other resources, or the protection of natural resources by conservation.

The following activities help consumers prevent pollution in their communities and allow to incorporate Pollution Prevention into the daily life.

- Reduce driving time
- Be careful with auto waste: Take used oil, auto batteries, and auto tyres to a recycling center or an appropriate disposal facility.
- Plant trees and shrubs
- Limit household hazardous waste
- Be careful with pesticides: Apply pesticides such as insecticides and herbicides carefully if they must be used.
- Beware of the dangers of lead to children
- Be an environmental consumer

  The following items will help you become an environmental consumer:

  - Reuse and recycle paper, glass, plastic, aluminum, scrap metal, and yard wastes;
  - Look for recycling symbol on products you buy. Such symbols identify recycled or recyclable products;
  - Avoid buying products that use unnecessary packaging – either plastic or paper;
  - Buy household goods and foods in bulk to minimize packaging waste;
  - Buy rechargeable batteries for flashlights, toys, and household items;

- Carry your own reusable shopping bag;
- Consider using reusable mugs, glasses, dishes, cloth towels;
- Encourage your community and your institution to begin recycling;
- Maintain and repair products;
- Patronize local businesses and buy locally produced foods and goods, both to promote a vital local community and prevent pollution generated by travel and shipping.

The following tips promote polution prevention and will help to curb energy use at home.

- Purchase Energy Efficient Products and Equipment
- Insulate the house
- Insulate pipes and fixtures
- By using a low-flow showerhead, you reduce water consumption and energy usage to heat the water.
- Turn unused appliances and equipment off
- By replacing the light fixtures with energy conserving fluorescent bulbs, you will save 75% of the energy used with incandescent bulbs.
- Clean or replace filters regularly
- Increase natural light
- Reduce paper usage
- Use public transportation or carpool

5.10 DISASTER MANAGEMENT

5.10.1 Major and Minor Calamities

Natural calamities of different types and intensities affect nations all over the world. Because of the large size of the country, India often faces natural calamities like floods, cyclones and drought occurring fairly frequently in different parts of the country. At times, the same area is subjected to floods and drought situation in successive seasons or years. While not all natural calamities can be predicted and prevented, a state of preparedness and ability to respond quickly to a natural calamity can considerably mitigate loss of life and property and human suffering, and restore normalcy at the earliest. It is, therefore, of paramount importance that a plan of action for dealing with contingencies that arise in the wake of natural calamities is formulated and periodically updated.

BURNING TOPIC

Life Cycle Assessment (LCA)

Life cycle assessment (LCA) is a process of evaluating the effects that a product has on the environment over the entire period of its life, thereby increasing resource-use efficiency and decreasing liabilities. LCA has its roots in the 1960s, when scientists concerned about the rapid depletion of fossil fuels developed it as an approach to understanding the impacts of energy consumption. In the 1970s, the U.S. Environmental Protection Agency refined this methodology. At present, the ISO 14040 and 14044 standards describe the principles and guidelines for LCA.

LCA can be used to study the environmental impact of either a product or the function the product is designed to perform. LCA is commonly referred to as a "cradle-to-grave" analysis. Thus, LCA studies the environmental aspects and potential impacts throughout the product's life, from raw materials acquisition through production, use and disposal. The key elements of LCA are the following:

- Compiling an ***inventory*** of relevant inputs and outputs of a product system;
- ***Evaluating*** the potential environmental impacts associated with those inputs and outputs;
- ***Interpreting*** the results of the inventory analysis and impact assessment phases in relation to the objectives of the study.

LCA facilitates a comparison of environmental performances of various products and a single figure is needed for this purpose. Although there are several methods, yet it is still a controversial issue and no single widely accepted method exists. Three well-documented and used methods are *The Eco-Points method*, *The Environmental Priority System* and *the Eco-Indicator*. Greenhouse potential, Air acidification potential, Eutrophication potential, Human toxicity potential, and Air odor potential, etc., are examples for Eco-Indicators. Nowadays there are a number of softwares available for LCA, making the task simpler.

REVIEW QUESTIONS

Objective-Type Questions

1. Which of the following is an air pollutant?

(a) Nitrogen (b) Carbon monoxide

(c) Carbon dioxide (d) Oxygen

2. Which of the following statements about carbon monoxide is true?
(a) It is the result of incomplete combustion of fossil fuels.
(b) It is a foul smelling gas.
(c) It is harmless to human beings.
(d) All of the above.

3. Which of the following is a secondary air pollutant?
(a) Carbon monoxide (b) Sulphur dioxide
(c) Ozone (d) Carbon dioxide

4. Smog is
(a) a natural phenomenon (b) a combination of smoke and fog
(c) is colourless (d) all of these

5. Which of the following are likely to be present in photochemical smog?
(a) Ozone (b) Peroxy acetyl nitrates
(c) Aldehydes (d) All of these

6. Which of the following air pollution control devices is suitable for removing the finest dust from the air?
(a) Settling chamber (b) Cyclone separator
(c) Fabric filter (d) Electrostatic precipitator

7. Which of the following devices is suitable for the removal of gaseous pollutants?
(a) Cyclone separator (b) Fabric filter
(c) Electrostatic precipitator (d) Wet collector (scrubber)

8. Air pollution from automobiles can be controlled by fitting?
(a) Electrostatic precipitator (b) Wet collector (scrubber)
(c) Catalytic converter (d) All of these

9. What is the permissible range of pH for drinking water as per the Indian standards?
(a) 6 to 9 (b) 6.5 to 7.5
(c) 6 to 8.5 (d) 6.5 to 8.5

10. What is the maximum allowable concentration of fluorides in drinking water?
(a) 1.0 milligram per liter (b) 1.25 milligram per liter
(c) 1.50 milligram per liter (d) 1.75 milligram per liter

11. Excess fluorides in drinking water is likely to cause

(a) blue babies
(b) fluorosis
(c) taste and odour
(d) intestinal irritation

12. Excess of iron in water is likely to cause

(a) colour
(b) taste
(c) hardness
(d) all of these

13. Which of the following is a nonpoint source of water pollution?

(a) Factories
(b) Sewage treatment plants
(c) Urban and suburban lands
(d) All of these

14. Sanitary sewage/domestic sewage is

(a) wastewater generated from kitchens and bathrooms
(b) wastewater generated from residential areas
(c) water entering a sewer as a result of rainfall
(d) wastewater from industries

15. For Indian conditions which of the following sewerage systems is ideal?

(a) Combined system
(b) Separate system
(c) Partially combined or partially separate system
(d) All of the above

16. BOD is

(a) biochemical oxygen demand.
(b) a measure of the organic matter present in wastewater.
(c) usually less than COD.
(d) all of the above.

17. Activated sludge process is

(a) an aerobic attached growth treatment system.
(b) an aerobic suspended growth biological treatment system.
(c) an anaerobic attached growth biological treatment system.
(d) an anaerobic suspended growth treatment system.

18. Septic tank is
(a) an aerobic attached growth treatment system.
(b) an aerobic suspended growth biological treatment system.
(c) an anaerobic attached growth biological treatment system.
(d) an anaerobic suspended growth treatment system.

19. Constructed wetlands could be an ideal low cost water treatment system for Indian conditions because
(a) tropical climate is ideal for the working of the system.
(b) wastewater in India is dilute.
(c) constructed wetlands are expensive.
(d) all of the above.

20. Reverse osmosis is a type of
(a) dead-end filtration system
(b) cross flow filtration system
(c) ion exchange method
(d) micro filtration

21. Which of the following is a major cause of soil pollution?
(a) Accidents involving the vehicles that are transporting waste material.
(b) Pesticides and chemical fertilizers from agricultural lands.
(c) Improper solid waste disposal.
(d) All of the above.

22. Which of the following is not a marine pollutant?
(a) Oil
(b) Plastics
(c) Dissolved oxygen
(d) All of these

23. Which of the following is the largest contributor of oil into the sea?
(a) Oil reaching the oceans from land
(b) From offshore oil wells
(c) Oil spillage from tankers
(d) None of these

24. Noise is
(a) a loud sound
(b) an unwanted sound
(c) a constant sound
(d) a sound of high frequency

25. Which of the following is a major source of thermal pollution of water bodies?
(a) Sewage treatment plants
(b) Thermal power plants
(c) Solid waste disposal sites
(d) All of these

26. Which of the following strategies should be given first preference as far as the management of plastic waste is concerned?
(a) Recycle
(b) Reuse
(c) Reduce the usage
(d) None of these

27. When the solid waste consists of large amounts of organic matter and if the moisture content is high, which of the methods of treatment will be ideal?
(a) Incineration
(b) Palletizing
(c) Recycle
(d) Composting

28. Which of the following is a likely characteristic of hazardous waste?
(a) Ignitability
(b) Corrosivity
(c) Reactivity
(d) Any of these

29. High-level radioactive waste can be managed in which of the following ways?
(a) Composting
(b) Store indefinitely
(c) Incineration
(d) Neutralization

30. Biomedical waste may be disposed of by
(a) incineration
(b) autoclaving and land filling
(c) both (a) and (b)
(d) none of these

31. One of the major reasons for the accumulation of e-waste in recent years is
(a) lack of technologies for recycling.
(b) rapid technology obsolescence.
(c) lack of strict regulations.
(d) all of these

Short-Answer Questions

1. Define air pollution.

2. Classify the major sources of air pollution.

3. List the major physiological effects of air pollution on plants.

4. Differentiate between primary and secondary air pollutants with examples.

5. Differentiate between smog and photochemical smog.

6. Define the following terms:
(i) Sewer
(ii) Sewage
(iii) Sullage
(iv) Storm drainage

7. Differentiate between sewage and sewerage.

8. Differentiate between point and non-point sources of pollution.

9. What are the major sources of ocean pollution?

10. Define soil pollution.

11. Define marine pollution.

12. Classify the sources and effects of marine pollution.

13. Why is it necessary to consider all the possible alternatives before deciding to dump anything into the ocean?

14. Enumerate the land sources of marine pollution.

15. List the offshore sources of marine pollution.

16. Define noise.

17. List the common sources and effects of noise.

18. Mention the unit of measurement of noise intensity level.

19. Define thermal pollution.

20. What are the impacts of thermal pollution on aquatic life?

21. Differentiate between recycling and reuse.

22. Define the following terms:
 (i) Municipal solid waste
 (ii) Refuse
 (iii) Hazardous waste

23. List the advantages of recycling of MSW with examples.

24. Define composting.

25. Differentiate between composting and vermicomposting.

26. List the common organic materials that are suitable and unsuitable for composting.

27. List the wastes that are prohibited from processing along with MSW.

28. List the types of hazardous wastes.

29. List the methods of disposal of hazardous waste.

30. Mention the methods of disposal of various types of radioactive wastes.

31. Explain the term NIMBY.

32. What is the significance of keeping hazardous substances in the original container?

33. Differentiate between pollution prevention and pollution control.

Descriptive Questions

1. List the major air pollutants and explain their effects on human beings.

2. Explain the conditions favouring the formation of photochemical fog and list the chemical reactions responsible.

3. Explain acid rain and its impacts. How can we avoid it?

4. List the major pollutants in the automobile exhaust and discuss the ways and means to control the same.

5. Discuss the methods of control of air pollution from automobiles.

6. Explain the working of a catalytic converter with a neat sketch.

7. Explain the working of the following air pollution control equipments, mentioning their advantages, disadvantages and applications.

(i) Cyclone separator (ii) Fabric filter

(iii) Electrostatic precipitator (iv) Wet collector (scrubber)

8. List the major contaminants of concern in the sewage and explain their effects.

9. Classify the sewage treatment methods.

10. Differentiate between combined and separate systems of sewerage.

11. Explain the significance of dissolved oxygen in rivers.

12. What are the common primary treatment techniques for sewage? Explain.

13. Classify and explain the various biological treatment methods for sewage.

14. Explain the activated sludge process with a flow diagram.

15. Explain the trickling filter process with a flow diagram.

16. Discuss how the symbiotic relationship between algae and bacteria is useful in the treatment of sewage in an oxidation pond.

17. Explain the suitability of constructed wetlands for waste treatment in Indian conditions.

18. Compare and contrast activated sludge process and septic tank for treating sewage.

19. Explain the major water pollutants and their effects.

20. Discuss the major causes and effects of soil pollution.

21. Explain the various control measures for soil pollution.

22. Oceans are the ultimate sink for most of the waste we produce. Explain.

23. What are the steps needed for the abatement of marine pollution?

24. Explain the effects of oil pollution on the oceans.

25. Explain the contribution of transport sector towards noise pollution.

26. What are the impacts of noise on human beings?

27. Explain the concept of source, path receiver in the control of noise pollution.

28. What are the human activities contributing to large-scale thermal pollution?

29. List the methods of waste management in the order of preference.

30. Explain the source reduction method of solid waste management with examples.

31. What is the significance of carbon to nitrogen ratio in composting?

32. Classify the composting techniques based on oxygen use.

33. What are the factors affecting the process of composting? Explain.

34. Explain the various classifications of the composting process. In your opinion, which one will be ideal for Indian conditions?

35. What are the advantages of vermicomposting over conventional composting?

36. What is the purpose of a landfill?

37. What are the advantages of solid waste incineration?

38. What are the major obstacles in the implementation of incineration technology in developing countries?

39. Write short notes on the health problems associated with the MSW handling personnel.

40. What is meant by illegal dumping of MSW? What are its causes, effects and control measures?

41. Explain the hierarchy of MSW management options.

42. With the help of a flow diagram, explain the methods of separation of components of MSW and its processing.

43. Explain with a flow diagram the following:

(i) Power generation from MSW combustible components.

(ii) Biogasification of organic components of MSW.

44. List and explain the disposal and recycling options for the various components of MSW.

45. Explain the process of composting as applied for the management of MSW.

46. Explain the points to be considered in the safe and efficient management of an engineered landfill.

47. What are the materials suitable for disposal by incineration? Is this method suitable for solid waste with high moisture content?

48. Explain the advantages and disadvantages of disposal of MSW by incineration.

49. Explain the ideal options for the management of MSW in India from your view point.

50. Define hazardous waste.

51. List the legal provisions in the Environment (Protection) Act pertaining to hazardous waste.

52. Enumerate the methods to reduce the production of hazardous waste from industries.

53. Hazardous waste is a product of chemical industries. Comment on the statement.

54. Mention any four hazardous wastes originating from households and explain their management strategies.

55. Explain the management methods for infectious waste.

56. Compare and contrast, incineration with landfilling in the case of hospital waste.

57. Identify the hazardous waste generated within 5 km from your residence and propose methods for the management of the same.

58. Do you think the transport of hazardous chemicals through our highways is a public risk? What could be done to improve the situation?

59. List the various ways in which an individual can contribute towards pollution prevention in the society.

60. Discuss the status of disaster preparedness in India.

61. Explain the various steps that can be taken to tackle the frequently occurring disasters such as cyclones and landslides in India.

Answers to Objective-Type Questions

1. (b)	2. (a)	3. (c)	4. (b)	5. (d)	6. (d)	7. (d)
8. (c)	9. (d)	10. (c)	11. (b)	12. (d)	13. (c)	14. (b)
15. (c)	16. (d)	17. (b)	18. (d)	19. (a)	20. (b)	21. (d)
22. (c)	23. (a)	24. (b)	25. (b)	26. (c)	27. (d)	28. (d)
29. (b)	30. (b)	31. (d)				

6 SOCIAL ISSUES AND THE ENVIRONMENT

"A healthy ecology is the basis for a healthy economy."

Claudine Schneider

Learning Outcomes

On successful completion of this chapter, students will be able to:

- Define the term Sustainable Development and discuss the terms Ecological Footprint and Carrying Capacity.
- Identify and analyze the urban issues relating to energy and water and its solutions.
- Discuss the various aspects of environmental ethics and principles of green chemistry.
- Analyze and comment on the phenomena Global Warming, Ozone Hole and Acid Rain.
- Identify the pollution control agencies and regulations existing in India.
- Briefly outline the topics Nuclear Disasters, EIA, Risk Management, Polluter-Pays Principle, Precautionary Principle, and ISO 14000.

6.1 FROM UNSUSTAINABLE TO SUSTAINABLE DEVELOPMENT

The primary goal of sustainable development is to achieve a reasonable and equitably distributed level of economic well-being that can be perpetuated continually for many human generations.

The displacement of materials by industrial and agricultural activities causes the most severe anthropogenic stress on the natural system. Hence, the understanding of human-induced material flows and the comparison of this with natural flows is essential to promote sustainable development.

Sustainable development can be alternatively defined as *development that meets the needs of the present without compromising the ability of future generations to meet their own needs.*

The ecological definition is perhaps the clearest and most straightforward, measuring physical and biological processes and the continued functioning of ecosystems. Economic definitions are sharply contested between those who emphasize the "limits" to growth and carrying capacity, and those who see essentially no limits. Similar to global environmental change, sustainable development remains first and foremost a social issue.

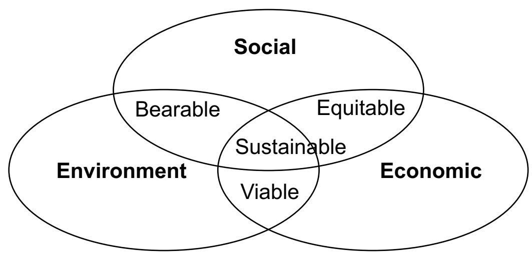


Fig. 6.1 *Schematic Representation of Sustainable Development*

6.1.1 Sustainability: Theory and Practice

Carrying Capacity

Consider a forest of fixed area with vegetation and deer on top of the foodchain. As the deer population increases, the food availability for each deer decreases and the maximum number of deer which can comfortably live in that forest for a long period of time is called the carrying capacity of that forest as far as deer population is concerned.

The carrying capacity is the number of individuals an environment can support without degradation.

- The level of land use, human activity, or development for a specific area that can be accommodated permanently without an irreversible change in the quality of air, water, land, or plant and animal habitats.

- The upper limits of development beyond which the quality of human life, health, welfare, safety, or community character within an area will be adversely affected.

Ecological Footprint (EF)

The Ecological Footprint is a measure of the load imposed by a given population on nature. It represents the land area necessary to sustain current levels of resource consumption and waste discharge by that population. Ecological footprint calculations are based on two simple facts:

1. We can estimate most of the resources we consume and many of the wastes we generate.
2. Most of these resource and waste flows can be converted to a biologically productive area necessary to provide these functions.

At present, the EF of the citizens of developed countries is much higher than that of their underdeveloped counterparts. The EF of many of the countries including India is much more than its actual area.

The biocapacity measures the bioproductive supply, i.e., the biological production in an area. It is an aggregate of the production of various ecosystems within the area, e.g., arable, pasture, forest, productive sea. Some of it is built or degraded land.

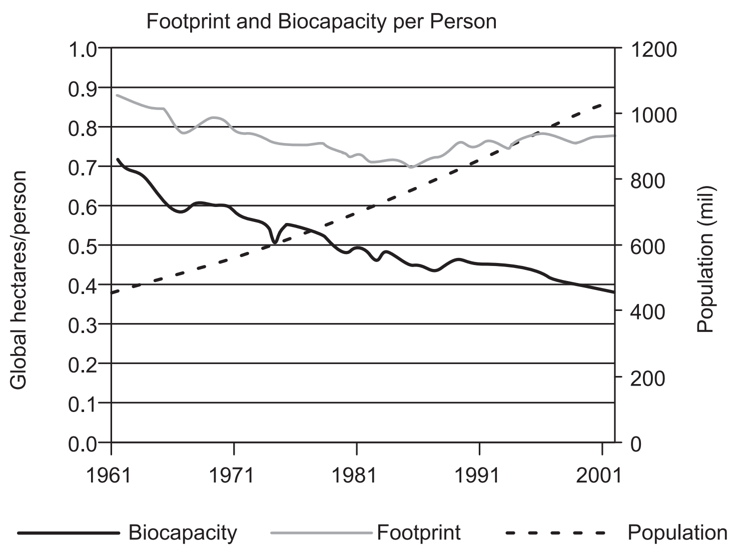


Fig. 6.2 *EF and Biocapacity of an Average Indian Citizen for the Period of 1961–2001*

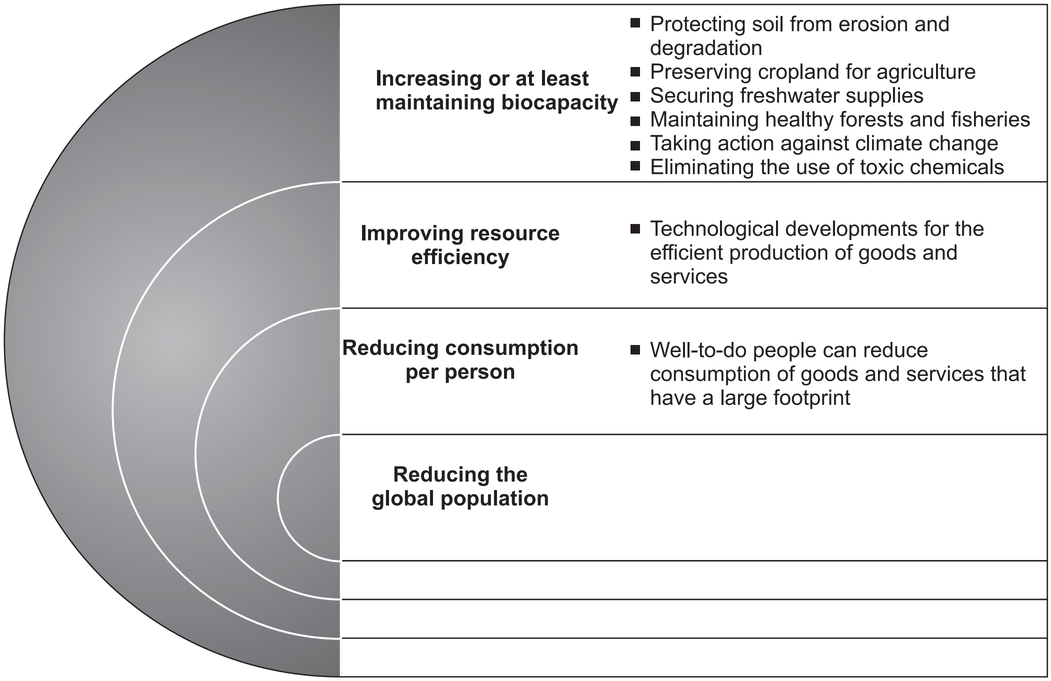


Fig. 6.3 *Strategies for the Reduction of Global Ecological Footprint*

Equitable Use of Resources for Sustainable Lifestyles

The basis of sustainable lifestyle for the protection of the environment is the use of three 'R's (*Reduce, Reuse and Recycle*).

Reduce The best thing that we can do for the planet is to use less of it. At the heart of the environmental crisis is our consumer society. Before you buy any thing new, ask yourself the following questions.

- Is there another product which would do the same thing but more sustainably?
- Will this last for a long time?
- Do I know how this item was made?
- How will it be used and how will it be disposed of?
- Where was this made and under what circumstances?
- Are the materials used to make this renewable?

6.2 URBAN PROBLEMS RELATED TO ENERGY

6.2.1 Urban Energy Crisis

Current patterns of energy use (especially based on fossil fuels) raise serious concerns for three reasons.

- The limited natural reserves of such energy
- Its detrimental effects on the global environment
- The threat to long-term sustainability

The three key issues that are likely to define the shape and future of energy in cities are the following:

- ***Sustainability***—how much and at what rate is energy consumed, and its effect on long-term sustainability; the quality and quantity of available alternative/renewable forms of energy; and the effect of existing energy use on the global environment as a whole.
- ***Efficiency***—the technology, planning and management of energy systems that will facilitate efficient use of energy for human activity.
- ***Equity***—the appropriate financial mechanism for research, development and use of finite and alternative energy forms, and their equitable distribution for all human kind.

6.2.2 Renewable Energy

Renewable energy is seen as an effective option for ensuring access to modern energy services in our vast country. In addition, it also provides a degree of national energy security. Renewable energy sources are clean and inexhaustible; however, continuous availability, reliability and initial investment are yet to be overcome for nationwide implementation.

The Ministry of nonconventional energy sources, Government of India is involved in the implementation of these programmes for the development, demonstration and utilization of various renewable energy based technologies, such as the following:

- Solar thermal;
- Solar photovoltaics;
- Wind power generation and water pumping;

- Biomass combustion/co-generation;
- Small, mini, and micro hydro power;
- Solar power;
- Utilization of biomass–gasifiers, briquetting, biogas, improved *chulha* (cook-stove);
- Geothermal for heat applications;
- Power generation/energy recovery from urban, municipal and industrial wastes;
- Tidal power generation;
- Chemical sources of energy;
- Fuel cells;
- Alternative fuel for surface transportation and hydrogen energy, etc.

6.3 WATER CONSERVATION

6.3.1 Some Ancient Indian Methods of Water Conservation and Harvesting

The Indus Valley Civilization, that flourished along the banks of the river Indus and other parts of western and northern India about 5,000 years ago, had one of the most sophisticated urban water supply and sewage systems in the world.

6.3.2 Rainwater Harvesting

Rainwater harvesting essentially means collecting rainwater on the roofs of buildings and storing it underground for later use. Not only does this recharging arrest groundwater depletion, it also raises the declining water table and can help augment water supply. Rainwater harvesting and artificial recharging are becoming very important issues. It is essential to stop the decline in groundwater levels, arrest sea-water ingress, i.e. prevent sea-water from moving landward, and conserve surface water run-off during the rainy season.

- *Traditional rainwater harvesting,* which is still prevalent in rural areas, was done in surface storage bodies like lakes, ponds, irrigation tanks, temple tanks, etc.

- *Modern methods of rainwater harvesting* The modern methods of rainwater harvesting are categorized as

1. *Artificial Recharging*
   - Absorption Pit Method

- ❍ Absorption Well Method
- ❍ Well cum Bore Method
- ❍ Recharge trench cum injection well

2. *Rainwater Harvesting*

- ❍ Percolation Pit Method
- ❍ Bore Well with Settlement Tank
- ❍ Open Well Method with Filter Bed Sump
- ❍ Percolation Pit with Bore Method

A typical rainwater harvesting facilty for a building is shown in Fig. 6.4.

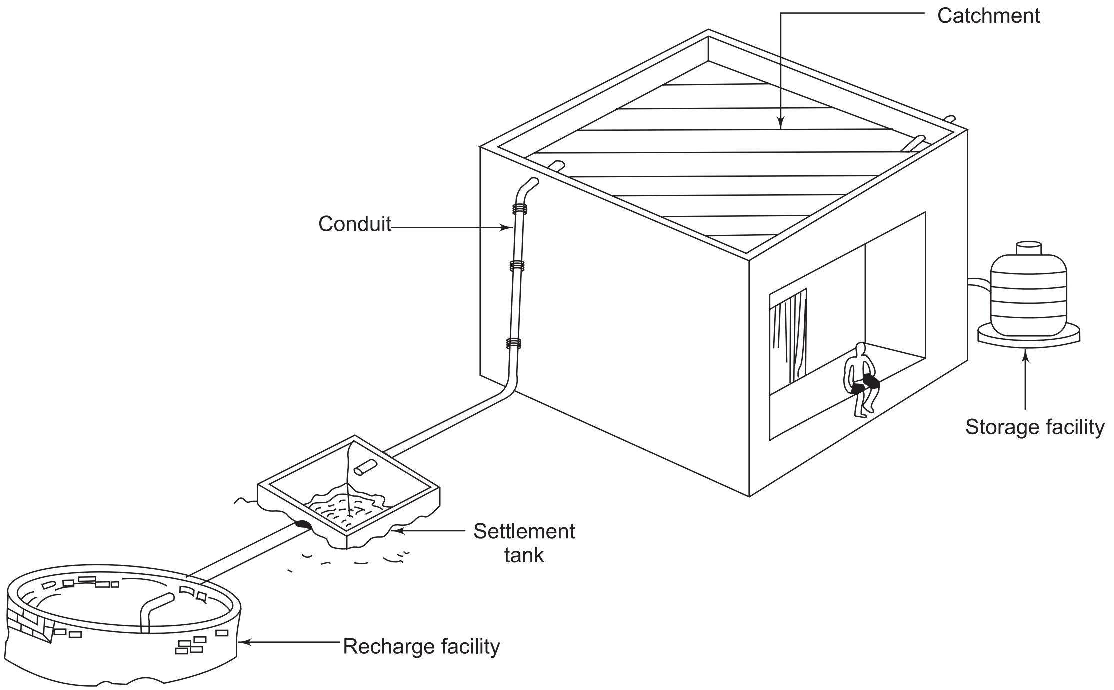


Fig. 6.4 *Typical Rainwater Harvesting Facility for a Building*

6.3.3 Reducing Water Demand in Agriculture

Simple techniques can be used to reduce the demand for water in irrigation. The underlying principle is that only part of the rainfall or irrigation water is taken up by plants, the rest percolates into the deep groundwater, or is lost by evaporation from the surface. Some of the methods by which substantial savings in water can be brought about in agriculture are listed below.

- Mulching, i.e., the application of organic or inorganic material such as plant debris, compost, etc., slows down the surface run-off, improves the soil moisture, reduces evaporation losses and improves soil fertility.
- Soil covered by crops, slows down run-off and minimizes evaporation losses. Hence, fields should not be left bare for long periods of time.
- Ploughing helps to move the soil around. As a consequence, it retains more water and thereby reduces evaporation.
- Shelter belts of trees and bushes along the edge of agricultural fields slow down the wind speed and reduce evaporation and erosion.
- Planting of trees, grass, and bushes breaks the force of rain and helps rainwater penetrate the soil.
- Fog and dew contain substantial amounts of water that can be used directly by adapted plant species. Artificial surfaces such as netting surfaced traps or polyethylene sheets can be exposed to fog and dew. The resulting water can be used for crops.
- Contour farming is adopted in hilly areas and in lowland areas for paddy fields. Farmers recognize the efficiency of contour-based systems for conserving soil and water.
- Salt-resistant varieties of crops have also been developed recently. Because these grow in saline areas, overall agricultural productivity is increased without making additional demands on freshwater sources. Thus, this is a good water conservation strategy.
- Transfer of water from surplus areas to deficit areas by interlinking water systems through canals, etc.
- Desalination technologies such as distillation, electrodialysis and reverse osmosis are available.
- Use of efficient watering systems such as drip irrigation and sprinklers will reduce the water consumption by plants.
- Greenhouse/Polyhouse farming can save water along with improved pest control and higher yields.
- Irrigation in the night will reduce the loss of water by evaporation.

6.4 WATERSHED MANAGEMENT

The term watershed describes an area of land that drains down slope to the lowest point. The water moves through a network of drainage pathways, both underground and on the surface. Generally, these pathways converge into streams and rivers, which become progressively larger as the water moves on downstream, eventually reaching an estuary and the ocean. Other terms used interchangeably with watershed include *drainage* basin or *catchment basin*. Watersheds can be large or small.

As a form of ecosystem management, watershed management encompasses the entire watershed system, from uplands and headwaters, to floodplain wetlands and river channels. It focuses on the processing of energy and materials (water, sediments, nutrients, and toxics) downslope through the system. This routing of groundwater and overland flow defines the delivery patterns to particular streams, lakes, and wetlands and largely shapes the nature of these aquatic systems. Watershed management requires the use of social, ecological, and economic sciences.

6.5 ENVIRONMENTAL ETHICS

Environmental ethics is the discipline that studies the moral relationship of human beings to, and also the value and moral status of, the environment and its nonhuman contents. The following is a typical list of questions investigated by environmental ethics.

- Suppose that putting out natural fires or destroying some individual members of overpopulated indigenous species is necessary for the protection of the integrity of a certain ecosystem. Will these actions be morally permissible or even required?
- Is it morally acceptable for farmers in non-industrial countries to practise slash and burn techniques to clear areas for agriculture?
- Consider a mining company which has performed open pit mining in some previously unspoiled area. Does the company have a moral obligation to restore the landform and surface ecology?

6.6 GREEN CHEMISTRY AND ITS TWELVE PRINCIPLES

Green chemistry, also called sustainable chemistry, is a philosophy of chemical research and engineering that encourages the design of products and processes that minimize the use and generation of hazardous substances. Whereas environmental chemistry is the chemistry of the natural environment, and of pollutant chemicals in nature, green chemistry seeks to reduce and prevent pollution at its source.

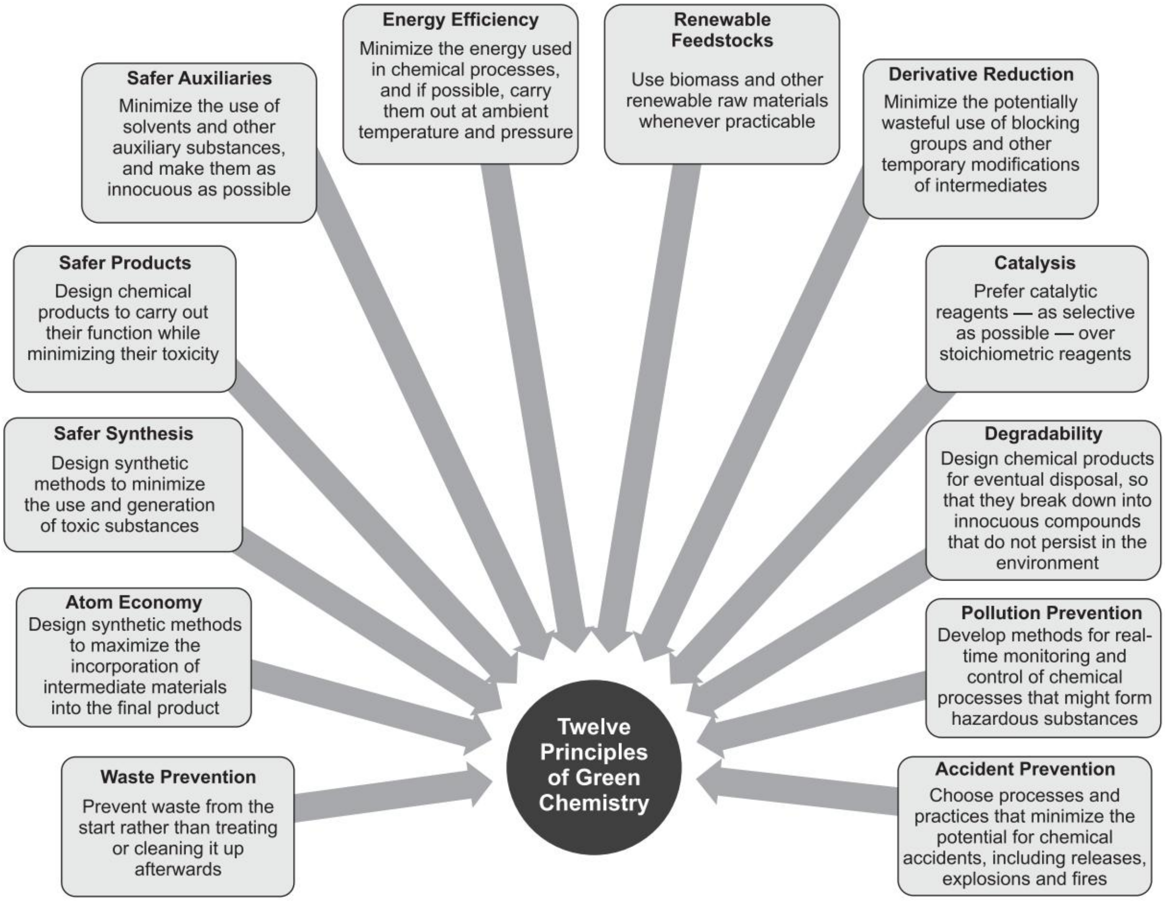


Fig. 6.5 *Twelve Principles of Green Chemistry*

6.7 ACID RAIN

Unpolluted rain water is slightly acidic owing to the presence of carbon dioxie in the air. Its pH could be up to 5.7.

$$CO_2(g) + H_2O(l) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$$

Therefore, rain water with pH values lower than 5.7 is called acid rain.

The primary cause of acid rain is sulphur dioxide and is released from burning of fossil fuels and industrial plants.

The formation of sulphur trioxide from sulphur dioxide is influenced by the prevailing atmospheric conditions such as the following:

- Sunlight
- Temperature
- Humidity
- Presence of hydrocarbons
- Nitrogen oxides
- Particulates

Besides the formation of sulphuric acid, many times in the atmosphere sulphurous acid is also formed.

6.7.1 Effects of Acid Rains

- *Vegetation* Acid rain can wash away essential plant nutrients from the soil. In addition, it makes the soil acidic and aids the release of aluminium and copper ions which are harmful to plants.

- *Aquatic life* When pH is less than 4.5, calcium metabolism in fresh water fish will be affected, leading to poor health. As a result, diversity and population of some fish species will be reduced.

- *Building materials* Acid rain will cause damage to common building materials (such as limestone and marble), in addtion to damaging statues and monuments.

$$CaCO_3(S) + 2H^+(aq) \longrightarrow Ca^{2+}(aq) + CO_2(g) + H_2O(l)$$

Many metals become oxidized. Iron corrodes with the presence of acid rain to form rust. The cost of maintenance of iron stuctures is high in highly polluted areas.

$$Fe(s) + 2H^+(aq) \longrightarrow Fe^{2+}(aq) + H_2(g)$$

6.8 OZONE-LAYER DEPLETION

Ozone (O_3) occurs naturally in the atmosphere. The earth's atmosphere is composed of several layers and is illustrated in Fig. 6.6.

Ozone forms a layer in the stratosphere, thinnest in the tropics (around the equator) and denser towards the poles. Ozone is formed in the atmosphere when ultraviolet radiation from the sun strikes the stratosphere, splitting oxygen molecules (O_2) into atomic oxygen (O). The atomic oxygen quickly combines with further oxygen molecules to form ozone.

$$O_2 + hv \rightarrow O + O \qquad (6.1)$$

$$O + O_2 \rightarrow O_3 \qquad (6.2)$$

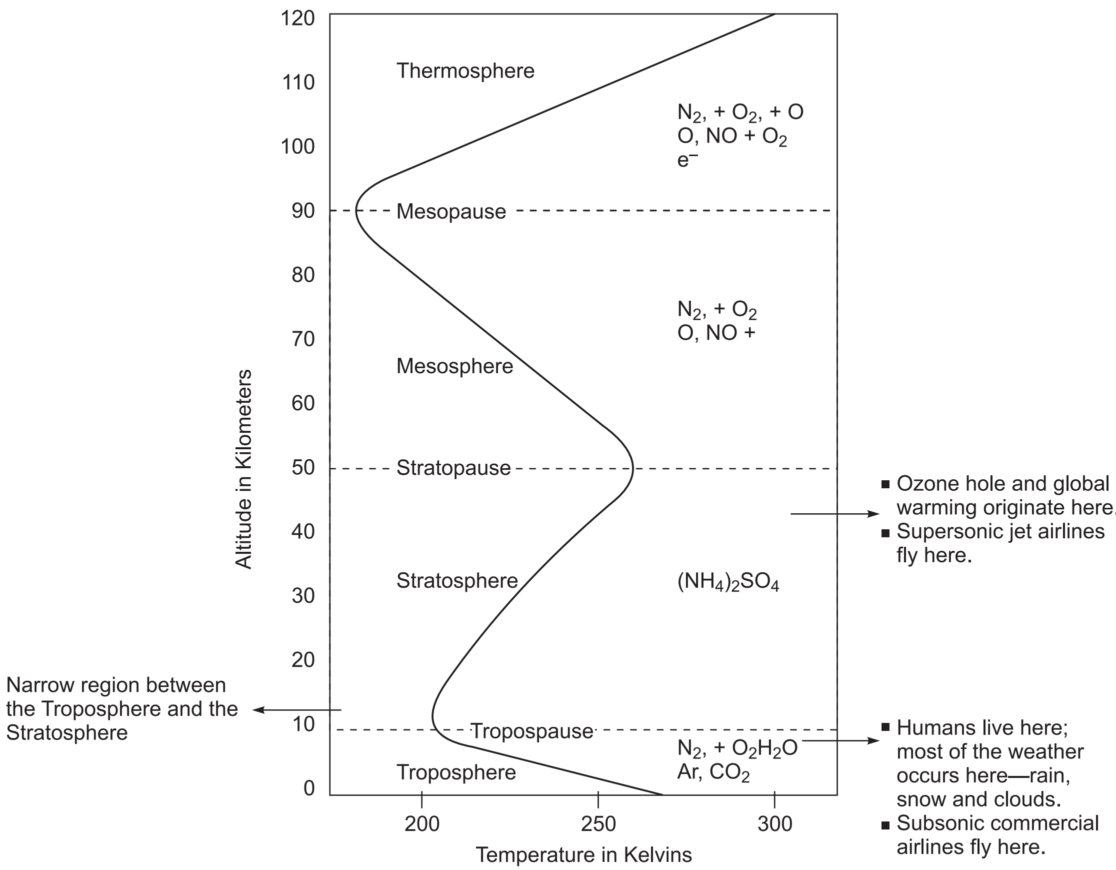


Fig. 6.6 *Various Layers of the Atmosphere*

At ground level, ozone is a health hazard and is a major constituent of photochemical smog. However, in the stratosphere we need ozone to absorb some of the potentially harmful ultraviolet (UV) radiation from the sun (at wavelengths between 240 and 320 nm) which can cause skin cancer and damage vegetation.

Figure 6.7 shows a schematic sketch of the lifecycle of the CFCs (Chlorofluorocarbons) which are identified as the major culprit in ozone destruction. CFCs were commonly used as refregerents and as propellant in spray cans. When these compounds escape into the atmosphere, they reach the stratosphere intact as they are basically inert compounds. In the stratosphere, the CFCs are broken down by the sunlight releasing chlorine atoms. These chlorine atoms act as catalysts in the destruction of O_3.

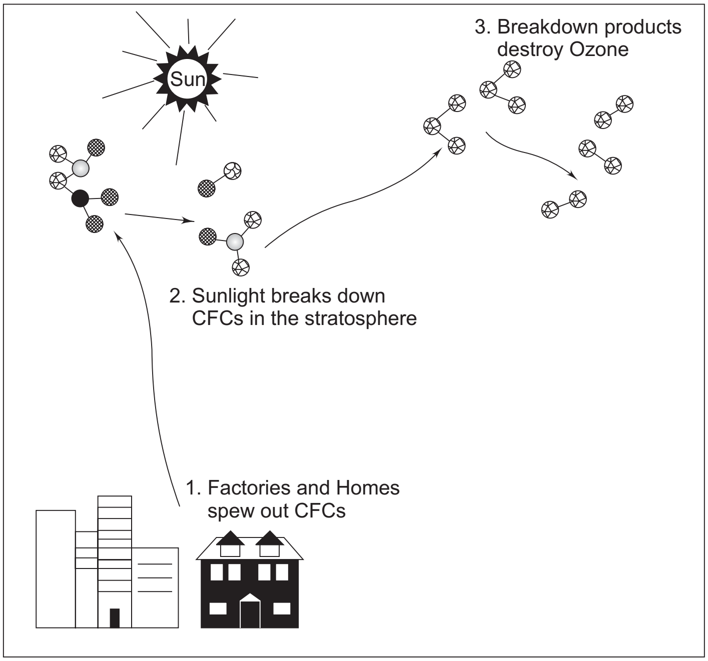


Fig. 6.7 *CFCs and Ozone Destruction*

6.8.1 Chlorofluorocarbons

Chlorofluorocarbons or CFCs (also known as Freon) are non-toxic, non-flammable and non-carcinogenic. They contain fluorine atoms.

The following is a list of major uses of CFCs:

- as coolants in refrigerators and air conditioners
- as solvents in cleaners, particularly for electronic circuit boards
- as a blowing agent in the production of foam (for example fire extinguishers)
- as propellants in aerosols

CFCs have a lifetime in the atmosphere of about 20 to 100 years, and as a result one free chlorine atom from a CFC molecule can do a lot of damage, destroying ozone molecules for a long time.

6.8.2 Measuring Ozone Depletion

The most common stratospheric ozone measurement unit is the Dobson Unit (DU).

The average amount of ozone in the stratosphere across the globe is about 300 DU. When stratospheric ozone falls below 200 DU, this is considered low enough to represent the beginnings of an ozone hole. Ozone holes commonly form during springtime above Antarctica, and to a lesser extent in the Arctic.

The ozone is being destroyed because of the release of chlorofluorocarbons (CFCs), mostly in the northern hemisphere. These spread throughout the world and diffuse into the stratosphere, where they are broken down to release chlorine.

The main long-lived inorganic carriers (reservoirs) of chlorine are hydrochloric acid (HCl) and chlorine nitrate ($ClONO_2$). These form from the breakdown products of the CFCs.

6.8.3 Impacts of Ozone Depletion

UV radiation from the Sun can cause a variety of health problems in humans, including skin cancers, eye cataracts and a reduction in our natural immunity towards many diseases. Furthermore, UV radiation can be damaging to microscopic life in the oceans which forms the basis of the world's food chain, certain varieties of vegetation including rice and soya crops, and polymers used in paints, clothing and other materials. Health disorders, damage to plant and aquatic life, and degradation of materials will probably increase. Ozone depletion may even affect the global climate.

6.8.4 Steps to Protect the Ozone Layer

The fundamental principle behind the actions to protect the ozone layer is to eliminate the usage of ozone depleting substances by replacing them with feasible substitutes or better technology.

There are a number of steps that we can all take both as individuals and as groups to protect the Earth's ozone layer.

Following the Montreal Protocol, most ozone depleting chemicals (ODCs) have been or are being phased out of use in most target applications such as aerosols, refrigeration and air conditioning.

Avoid any fire extinguishers that contain halons, which have bromine in them. Instead use carbon dioxide, water, or dry chemical extinguisher. Although foam packaging is CFC-free, some products contain HCFCs (hydrochlorofluorocarbons), which, while far less damaging to the ozone layer, could contribute substantially to global warming. Hence avoid them and re-use nondisposable packaging.

As per the 2015 research reports from MIT, the antarctic ozone hole is shrinking and healing. This shows that the Montreal Protocol is effective.

6.9 GREENHOUSE EFFECT, GLOBAL WARMING AND CLIMATE CHANGE

The greenhouse effect is a naturally occurring process that aids the heating of the Earth's surface and atmosphere. It results from the fact that certain atmospheric gases, such as carbon dioxide, water vapour, and methane, are capable of changing the energy balance of the planet by being able to absorb long wave radiation from the earth's surface. The term "greenhouse" is used to describe this phenomenon since these gases act like the glass of a greenhouse to trap heat and maintain higher interior temperatures than would normally occur. Without the greenhouse effect, it is not possible to sustain life on this planet as the average temperature of the Earth would be –18°C rather than the present 15°C.

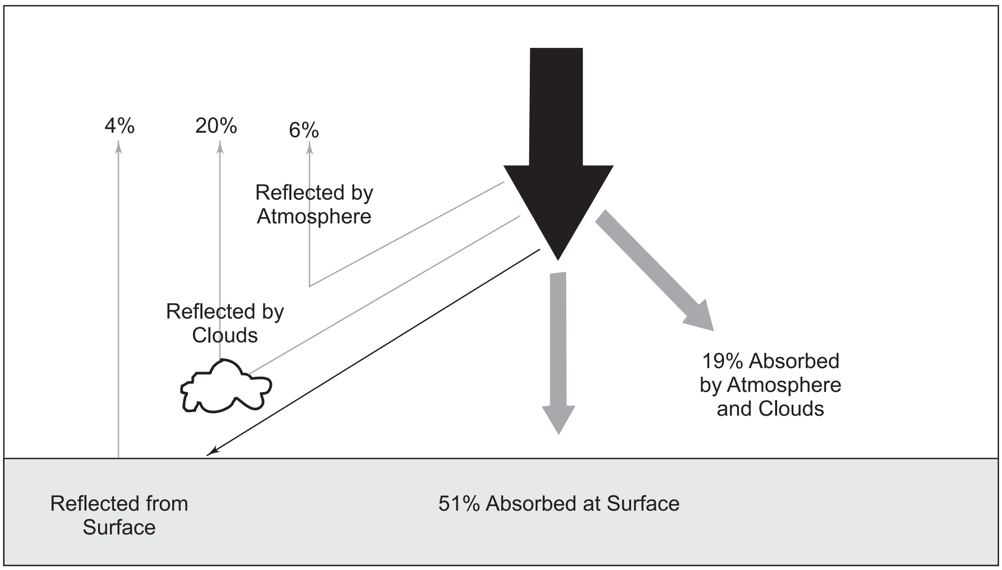


Fig. 6.8 *Reflection and Absorption Pattern of Solar Radiation on Earth*

On an average, about 51% of the sun's radiation reaches the surface.

The amount of heat energy added to the atmosphere by the greenhouse effect is controlled by the concentration of greenhouse gases in the Earth's atmosphere. All of the major greenhouse gases have increased in concentration since the beginning of the industrial revolution. As a result of these higher concentrations, scientists predict that the greenhouse effect will be enhanced and the Earth's climate will become warmer and this is referred to as **global warming**.

A number of gases are involved in the greenhouse effect. These gases include: carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); chlorofluorocarbons (CF_xCl_x); and tropospheric ozone (O_3). Of these gases, the single most important gas is carbon dioxide which accounts for about 55% of the change in the intensity of the earth's greenhouse effect.

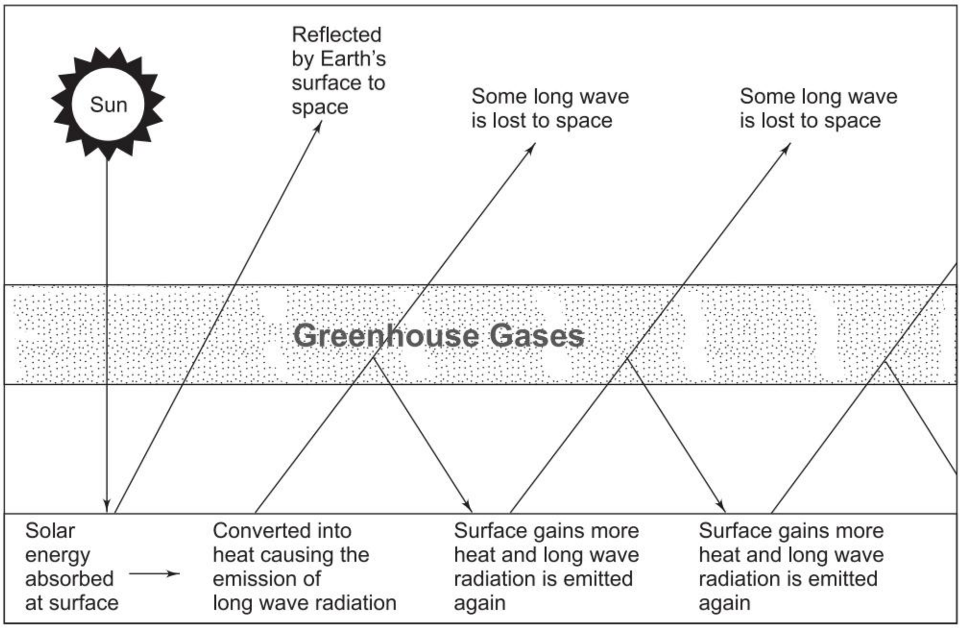


Fig. 6.9 *Greenhouse Effect*

Global warming is already having significant and visible harmful effects on our society, health, and climate. Sea level rise is accelerating, and the number of large wildfire incidents is growing around the world. Dangerous heat waves are becoming more common and extreme climate events such as cyclones and droughts are increasing in many countries. It is time we took immediate action to address global warming or else these consequences will continue to intensify, and increasingly affect the entire planet. The good news is that we have the practical solutions at hand to dramatically reduce our carbon emissions, slow the pace of global warming, and pass on a healthier, safer world to our future generations.

6.9.1 Effects of Global Warming

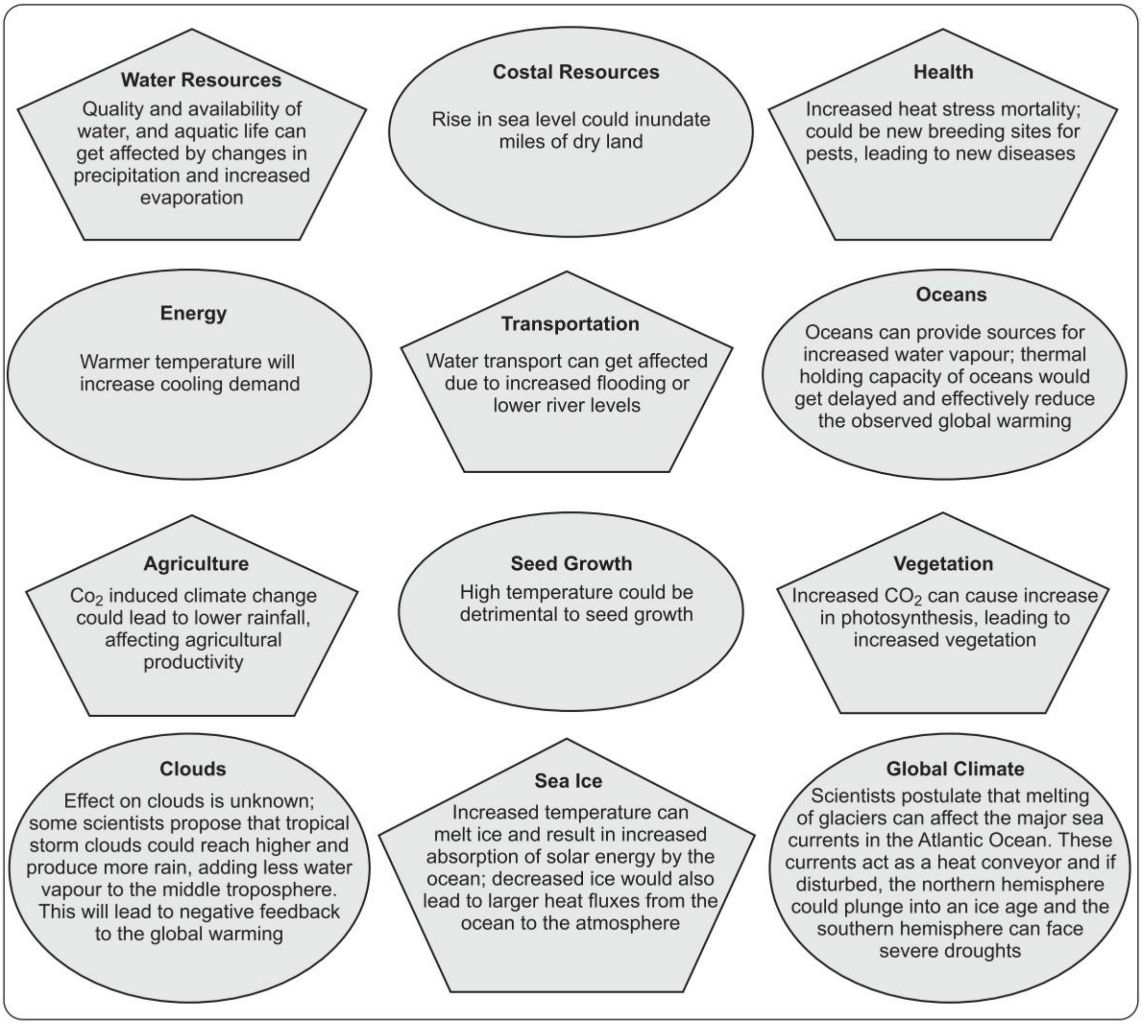


Fig. 6.10 *Effects of Global Warming*

6.9.2 Solutions for Global Warming

Clean electricity technologies including wind turbines, solar panels and hydrogen fuel cells are continually improving, becoming more efficient, economical, and capable of competing with polluting gas and coal power plants.

Biofuels including ethanol and biodiesel could substantially cut down the carbon dioxide emission from automobiles.

Sustainable farming and forestry techniques lock up carbon in plants and soils and provide new revenues to rural communities.

BURNING TOPIC

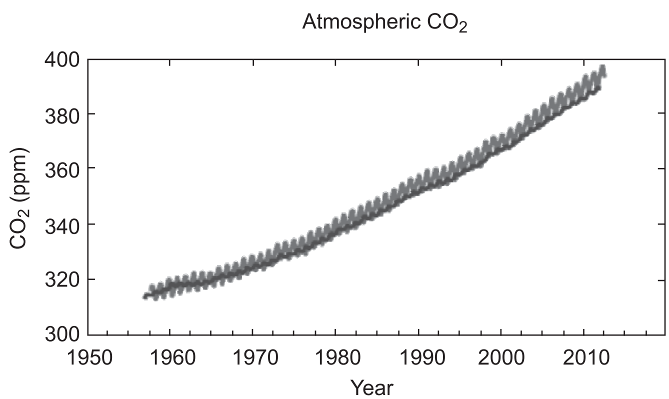
Climate Change: An Inconvenient Truth

Weather is the mix of events that happen every day in our atmosphere including temperature, rainfall and humidity. Climate is the average weather pattern in a place over many years.

Climates will change if the factors that influence them fluctuate. To change climate on a global scale, either the amount of heat that is let into the system changes, or the amount of heat that is let out of the system changes. For instance, warming climates are either due to increased heat let into the Earth or a decrease in the amount of heat that is let out of the atmosphere.

In the early 19th century, scientists discovered that trace amounts of atmospheric gases, including carbon dioxide and methane, were responsible for retaining some of the sun's heat in the lower atmosphere. They theorized that without these gases, the earth's temperature would not support the variety of life found on this planet. However, the huge amount of fossil fuels burned since the Industrial Revolution has increased the atmospheric concentration of these gases and dramatically changed the energy balance of the planet, retaining heat that otherwise would be radiated out into space. Like the glass in a greenhouse, this raises the average air temperature in the lower atmosphere.

The gases responsible for this phenomenon are known as **greenhouse gases (GHG)**. CO_2 is the major GHG and the other gases that could contribute this effect are identified as CH_4, N_2O, HFCs (hydrofluorocarbons), PFCs (perfluorocarbons) and SF_6 (sulphur hexafluoride) (Fig. 6.11).



(Source: IPCC 2013)

Fig. 6.11 *Atmospheric Concentrations of Carbon Dioxide (CO_2)*

Intergovernmental Panel on Climate Change (IPCC)

Recognizing the problem of potential global climate change, the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) established the Intergovernmental Panel on Climate Change (IPCC) in 1988.

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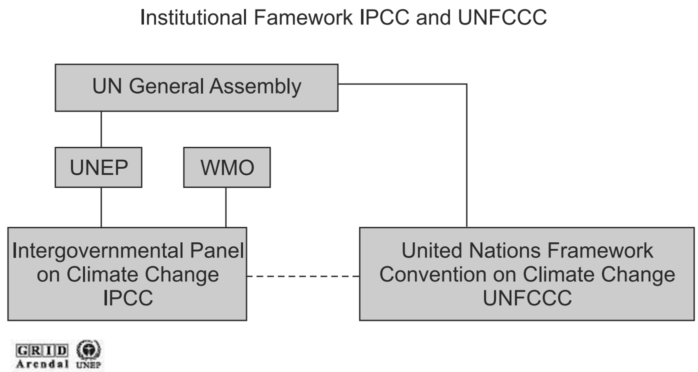

Fig. 6.12 *Institutional Framework of IPCC and UNFCCC*

6.10 POLLUTION CONTROL BOARDS AND CONTROL POLLUTION ACTS IN INDIA

The Government of India has formulated comprehensive legislations to enable the institutions like pollution control boards to effectively protect the environment.

6.10.1 Central Pollution Control Board (CPCB)

The principal functions of the CPCB, as spelt out in the Water (Prevention and Control of Pollution) Act, 1974, and the Air (Prevention and Control of Pollution) Act, 1981 are the following:

- To promote cleanliness of streams and wells in different areas of the States by prevention, control and abatement of water pollution.
- To improve the quality of air and to prevent, control or abate air pollution in the country.

6.10.2 The Water (Prevention and Control of Pollution) Act, 1974

The Water Act was enacted by Parliament Act, 1974 with the purpose to provide for the prevention of control of water pollution and maintaining or restoring of wholesomeness of water. As on day, it is applicable in all the states of India.

- No person shall knowingly cause or permit any poisonous, noxious or polluting matter determined in accordance with such standards as may be laid down by the State Board to enter (whether directly or indirectly) into any stream or well or sewer or on land;

- No person shall knowingly cause or permit to enter into any stream any other matter which may tend, either directly or in combination with similar matters, to impede the proper flow of the water of the stream in a matter leading or likely to lead to a substantial aggravation of pollution due to other causes or of its consequences.
- No person shall, without the previous consent of the State Pollution Control Board (SPCB):
  (a) establish or take any steps to establish any industry, operation or process, or any treatment and disposal system or an extension or addition thereto which is likely to discharge sewage or trade effluent into a stream or well or sewer or on land, or
  (b) bring into use any new or altered outlets for the discharge of sewage, or
  (c) begin to make any new discharge of sewage.

6.10.3 The Air (Prevention and Control of Pollution) Act, 1981

This is an Act to provide for the prevention, control and abatement of air pollution, for the establishment of boards with a view to carrying out the air pollution control and for conferring on and assigning to such Boards powers and functions relating thereto and for matters connected therewith.

6.10.4 The Environment (Protection) Act, 1986

In the wake of Bhopal tragedy, the Government of India enacted the Environment (Protection) Act, 1986 (EPA) under Article 253 of the Constitution. The purpose of the Act is to act as an "umbrella" legislation designed to provide a framework for Central Government co-ordination of the activities of various central and state authorities established under previous laws, such as Water Act and Air Act.

6.10.5 The Wildlife Protection Act, 1971

It emphasizes protection of wild and other animals within a broad ecological perspective. It provides for establishment of sanctuaries and national parks. It has provisions for dealing with zoos, trade in wild animals and for taking action for the specific protection of certain species.

6.10.6 The Forest (Conservation) Act, 1980

Under the provisions of this Act, prior approval of the Central Government is essential for diversion of forest lands for the non-forestry purposes.

6.10.7 Constitutional Provisions

India is the first country which has made provisions for the protection and improvement of environment in its Constitution. In the 42nd amendment to the Constitution in 1976, provisions to this effect were incorporated in the Constitution of India with effect from 3rd January, 1977. (The provision in Article 51-A (g) of the Constitution.) It stipulates that 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.

6.11 NUCLEAR HAZARDS AND ACCIDENTS

The visions a nuclear disaster can bring are horrific to say the least. In the past, they have been known to cause catastrophic destruction and loss of life. Unfortunately, these are just the immediate results. Those people who do survive may deal with chronic illness, physical, mental, and emotional disfunction, and an increased incidence of disease manifestations such as cancer.

By definition, radiation is a form of energy. It comes from man-made sources such as X-ray machines, from the sun and outer space, and from some radioactive materials such as uranium in soil. Small quantities of radioactive materials occur naturally in the air we breathe, the water we drink, the food we eat, and in our own bodies. Radiation that goes inside our bodies causes what we refer to as internal exposure. The exposure that is referred to as external comes from sources outside the body, such as radiation from sunlight and man-made and naturally occurring radioactive materials. Eighty percent of typical human exposure comes from natural sources and the remaining 20% comes from artificial radiation sources, primarily medical X-rays.

These adverse health effects can range from mild effects, such as skin reddening, to serious effects such as cancer and death, depending on the amount of radiation absorbed by the body, the type of radiation, the route of exposure, and the length of time a person is exposed. Exposure to very large doses of radiation may cause death within a few days or months. Exposure to lower doses of radiation may lead to an increased risk of developing cancer or other adverse health effects.

The following is a list of major nuclear disasters of the world.

- Fukushima, Japan - 2011
- Chernobyl, Russia - 1986
- Three Mile Island, US - 1979

6.11.1 Facts about Radiological Accidents

Some Important Facts about Radiation and Materials

- Radioactive materials are composed of atoms that are unstable. An unstable atom gives off its excess energy until it becomes stable. The energy emitted is radiation.
- The process by which an atom changes from an unstable state to a more stable state by emitting radiation is called radioactive decay or radioactivity.
- Radioactive materials are dangerous because of the harmful effect of certain types of radiation on the cells of the body. The longer a person is exposed to radiation, the greater the risk.
- People receive some radiation exposure each day from the sun, radioactive elements in the soil and rocks, household appliances like television sets and microwave ovens, and medical and dental X-rays.
- Radiation cannot be detected by sight, smell, or any other sense.
- Out of the ionizing radiation types (Alpha particles, Beta particles, Gamma rays and X-rays) Alpha particles can be stopped by a sheet of paper and cannot penetrate the human skin. Beta particles can be stopped by clothing or a thin sheet of aluminium. Whereas the Gamma rays and X-rays can be stopped only by thick concrete or lead walls.

6.11.2 Ways to Minimize Radiation Exposure

There are three factors that minimize radiation exposure to our body: Distance, Shielding, and Time.

❑ *Distance* The more distance between you and the source of the radiation, the less radiation you will receive. In a serious nuclear accident, local officials will likely call for an evacuation, thereby increasing the distance between you and the radiation.

❑ *Shielding* Like distance, the heavier, denser materials between you and the source of the radiation, the better. This is why local officials could advise you to remain indoors if a radiological accident occurs. In some cases, the walls in your home would be sufficient shielding to protect you.

❑ *Time* Most radioactivity loses its strength fairly quickly. Limiting the time spent near the source of radiation reduces the amount of radiation you will receive. Following a radiological accident, local authorities will monitor any release of radiation and determine when the threat has passed.

CASE STUDY

Chernobyl Nuclear Disaster

On April 25th–26th, 1986 the World's worst nuclear power accident occurred at Chernobyl in the former USSR (now Ukraine). The Chernobyl nuclear power plant located 80 miles north of Kiev had 4 reactors and while testing reactor number 4, numerous safety procedures were disregarded. At 1:23 am the chain reaction in the reactor became out of control creating explosions and a fireball which blew off the reactor's heavy steel and concrete lid.

The Chernobyl accident killed more than 30 people immediately, and as a result of the high radiation levels in the surrounding 20 mile radius, 135 00 people had to be evacuated. Figures from the Ukraine Radiological Institute suggest that over 2 500 deaths were caused by the Chernobyl accident.

Health and Psychological Consequences of Chernobyl

Health Effects

Increase in Thyroid Cancer. Between 1981 and 1985, the five years preceding the accident, the average thyroid cancer rate was 4-6 incidents per million Ukrainian young children (birth to 15 years). However between 1986 and 1997 this rose to 45 incidents per million. Researchers also found that 64% of all Ukrainian thyroid cancer patients age 15 of younger lived in the most contaminated regions (the provinces of Kiev, Chernigov, Zhitomir, Cherkassy, and Rovno and the city of Kiev)

Increase in Other Cancers. There have also been some reports in increases of specific cancers in certain populations living in contaminated areas and among liquidators. (Those who helped with the clean up of the accident)

Psychological Consequences

There have been significant increases in psychological health disorders and incidence such as:

- anxiety
- depression
- helplessness and despair leading to social withdrawal and loss of hope for the future
- other disorders attributable to mental stress

6.12 ENVIRONMENTAL IMPACT ASSESSMENT

Environmental Impact Assessment (EIA) is intended to identify the environmental, social and economic impacts of a proposed development prior to decision making.

6.12.1 Different Types of Impact Assessments

Environmental impact assessment could encompass the following types of impact assessments.

- Climate Impact Assessment
- Demographic Impact Assessment
- Development Impact Assessment
- Ecological Impact Assessment
- Economic and Fiscal Impact Assessment
- Environmental Auditing
- Environmental Impact Assessment
- Environmental Management Systems
- Health Impact Assessment
- Project Evaluation
- Public Consultation
- Public Participation
- Risk Assessment
- Social Impact Assessment
- Strategic Impact Assessment
- Technology Assessment

6.12.2 The Benefits of EIA

The following is a general overview of the many benefits offered by effective EIA.

- Reduced cost and time of project implementation.
- Cost saving modifications in project design.
- Increased project acceptance.
- Avoiding impacts and violations of laws and regulations.
- Improved project performance.
- Avoiding waste treatment/clean up expenses.

The benefits to local communities from taking part in environmental impact assessments include:

- A healthier local environment (forests, water sources, agricultural potential, recreational potential, aesthetic values, and clean living in urban areas)
- Improved human health
- Maintenance of biodiversity
- Decreased resource use
- Fewer conflicts over natural resource use
- Increased community skills, knowledge and pride

6.12.3 The EIA Process

The various stages of EIA process for a typical project is detailed in Fig. 6.13.

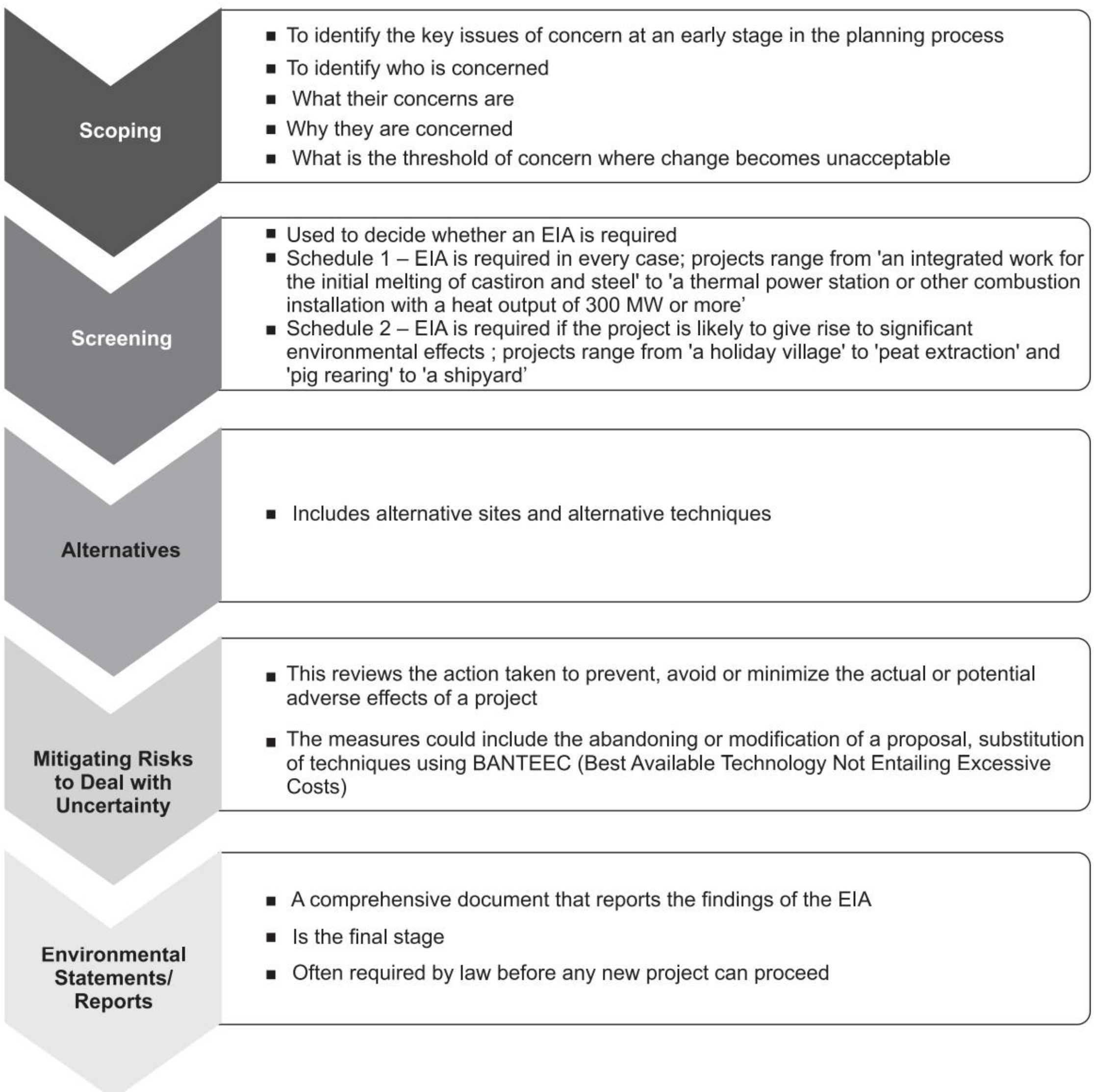

Fig. 6.13 *Environmental Impact Assessment Process*

6.12.4 Contents of a Typical Environmental Impact Assessment

- Description of the proposed activity.
- Analysis of site selection procedure and alternate sites.

- Baseline conditions/major concerns.
- Description of potential positive and negative environmental, social, economic and cultural impacts including cumulative, regional, temporal and spatial considerations.
- Significance of impacts under social, economic and cultural impacts including cumulative, regional, temporal and spatial considerations.
- Mitigation plans.
- Identification of issues related to human health.
- Consideration of alternatives, including not proceeding.
- Monitoring plans (impacts and mitigation efforts).
- Contingency plans for unpredicted impacts.
- Waste minimization and recycling plans.
- Public consultation programme.
- Plans to minimize release of adverse substances.
- Terms of reference.
- Any other information deemed necessary.

6.12.5 Participatory Monitoring and Evaluation

Evaluation activities tell project managers whether the mitigation measures prescribed during the EIA are working, and whether or not the project is having any unforeseen environmental impacts.

The classical approach is to recruit an expert who employs predetermined indicators to appraise the project's impact at specific points in its evolution. However, since the 1980s, it has become increasingly common for community projects in health, agriculture, or education to engage community members in monitoring and evaluation.

In meeting monitoring and evaluation objectives, any of the following simple techniques can be employed by communities:

- Interviews
- Group Discussions
- Questionnaires
- Observations
- Scientific testing (It has been proven that communities can undertake effective testing without sophisticated training)
- Maps, drawings or any other visual techniques that can accurately depict changes
- Before-and-after images captured by audio-visual equipment
- Other methods devised by the community

Any of the following criteria can be incorporated into the objectives of any project evaluation:

- Performance of project system (i.e. quality of building construction, irrigation system etc.)
- Human resource development (New skills acquired)
- Environmental sustainability
- Use and benefit
- Transformation of community attitudes towards environmental issues. Even though this may prove difficult to define and measure, it is still a legitimate focus for evaluation.

6.13 RISK MANAGEMENT

Risk management is defined as 'The overall process of risk identification, quantification, evaluation, acceptance, aversion and management.'

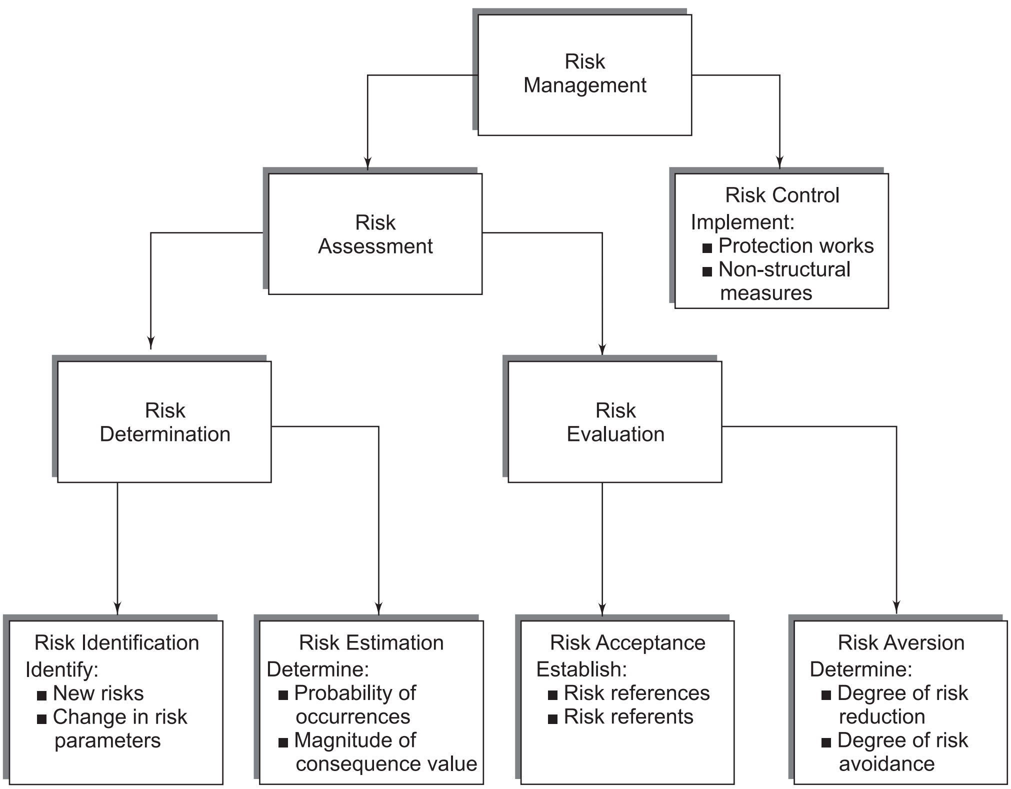

Fig. 6.14 *Steps in Risk Management*

6.14 PRECAUTIONARY PRINCIPLE

The Precautionary Principle is one of the key elements for policy decisions concerning environmental protection and management. It is applied in the circumstances where there are reasonable grounds for concern that an activity could cause harm but where there is uncertainty about the probability of the risk and the degree of harm.

The principle directs that action should be taken to correct a problem as soon as there is evidence that harm may occur, not after the harm has already occurred.

6.15 POLLUTER-PAYS PRINCIPLE

The principle is simple—those who pollute the environment must pay for the damages they have caused. As the Polluter-Pays Principle is only a payment method designed to finance pollution control activities, it cannot guarantee efficiency or cost effectiveness in environmental protection.

6.16 THE BENEFICIARY-PAYS PRINCIPLE

In a country where poverty and income inequality exist, another alternative payment method of pollution control could be considered—the Beneficiary-Pays Principle.

The Polluter-Pays Principle requires the poor commuters using public buses to pay a higher charge in order to finance cleaner and less smoky bus exhaust emission so that everyone can enjoy cleaner air. The alternative Beneficiary-Pays Principle argues that cleaner and less smoky buses should, instead, be financed by all the city residents and not just bus commuters since, after all, everyone will benefit from clean air.

6.17 THE ISO 14000 SERIES OF ENVIRONMENTAL MANAGEMENT STANDARDS

The ISO is a specialized international organization whose members are the national standards bodies of 111 countries. ISO was founded in 1946 to develop manufacturing, trade and communication standards, such as standard screw threads, shipping container sizes, video formats, and so forth. These standards are intended to facilitate international trade by increasing reliability and effectiveness of goods and services. All standards

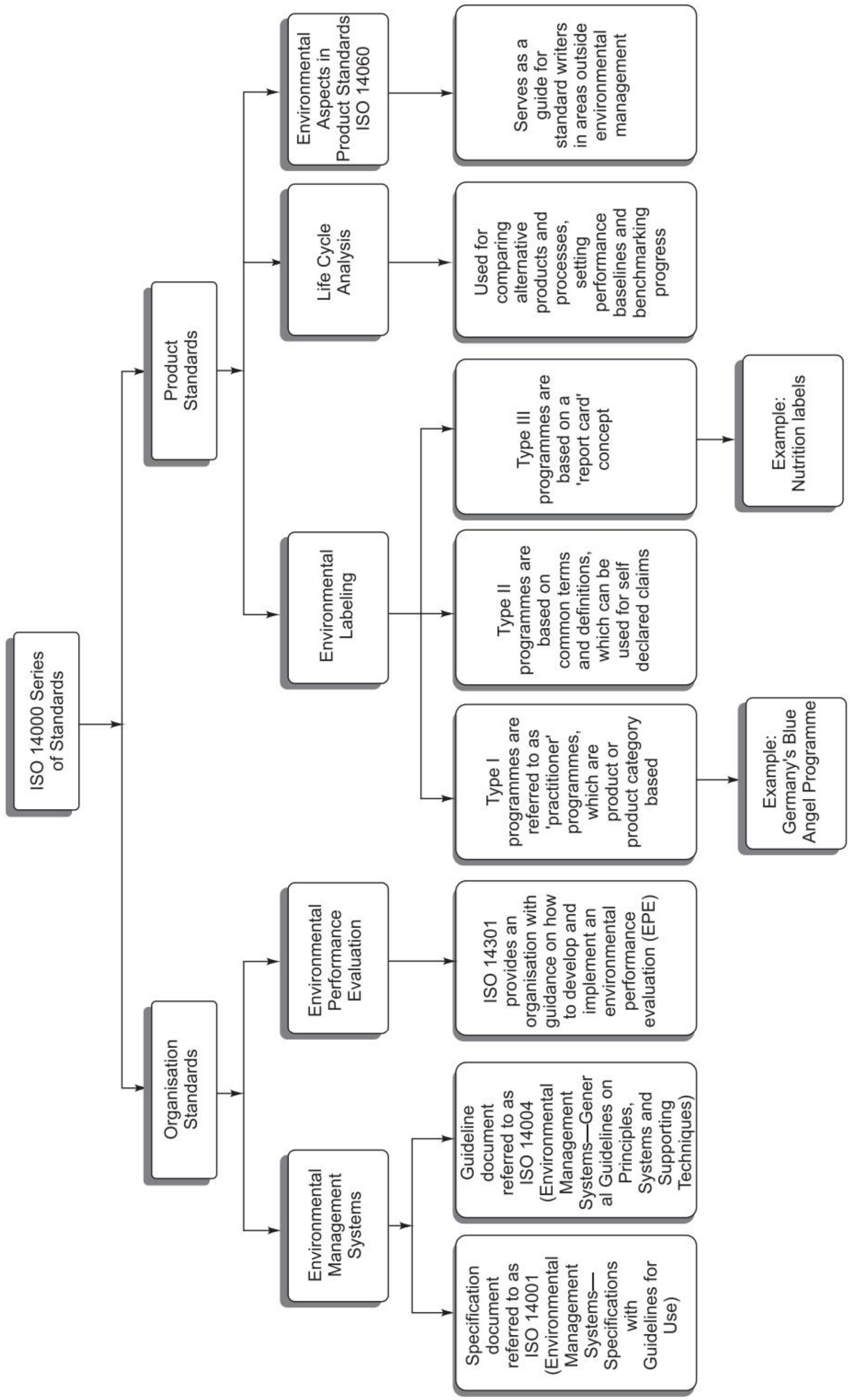

Fig. 6.15 *ISO 14000 Model*

developed by ISO are voluntary; however, countries often adopt ISO standards and make them mandatory. ISO 14000 is a series of international standards on environmental management.

The basic concept underlying the ISO 14000 series is that in order to consistently meet environmental performance expectations, an organization must implement and maintain an effective environmental management system.

6.18 ECONOMY AND ENVIRONMENT

According to environmental economists, environmental degradation is the result of the failure of the market system to put the deserving value on the environment, even though the environment serves economic functions and provides economic and other benefits.

6.18.1 Environmental Economics

Environmental economics is a branch of economics concerned with environmental issues. Environmental economics involves theoretical and empirical studies of the economic effects of national or local environmental policies around the world.

REVIEW QUESTIONS

Objective-Type Questions

1. Sustainable development will not aim at

(a) social economic development which optimizes the economic and societal benefits available in the present, without spoiling the likely potential for similar benefits in the future.

(b) reasonable and equitably distributed level of economic wellbeing that can be perpetuated continually.

(c) development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

(d) maximizing the present-day benefits through increased resource consumption.

2. Fossil-fuel based pattern of energy use is having the problem of

(a) limited natural reserve. (b) environmental pollution.

(c) lack of long-term sustainability. (d) all of these

3. Reduction in the usage of fossil fuels cannot be brought about by

(a) using alternative energy sources

(b) changing lifestyles

(c) reducing car taxes

(d) encouraging the use of mass transport systems such as buses and railways

4. Which of the following is not a method for water conservation?

(a) Rainwater harvesting (b) Groundwater extraction

(c) Improving irrigation efficiency (d) Avoiding water wastage

5. In India a major cause of large-scale displacement of people is

(a) forest fires (b) development projects such as dams

(c) earthquakes (d) war

6. Which of the following is an issue relevant in environmental ethics?

(a) Value of a humanly restored environment compared with the originally natural environment.

(b) Right of species other than human beings on this planet.

(c) Obligation of companies in environmental protection.

(d) All of the above.

7. The primary cause of acid rain around the world is

(a) carbon dioxide (b) sulphur dioxide

(c) carbon monoxide (d) ozone

8. Ozone layer is present in

(a) troposphere (b) stratosphere

(c) mesosphere (d) thermosphere

9. Which of the following statements about ozone is true?

(a) Ozone is a major constituent of photochemical smog

(b) Ozone protects us from the harmful UV radiation of the sun

(c) Ozone is highly reactive

(d) All of the above

10. A major compound responsible for the destruction of stratospheric ozone layer is
(a) oxygen (b) CFC
(c) carbon dioxide (d) methane

11. Ozone-layer thickness is measured in
(a) millimeters (b) centimeters
(c) decibels (d) Dobson units

12. Normal average thickness of stratospheric ozone layer across the globe is around
(a) 200 DU (b) 300 DU
(c) 400 DU (d) 500 DU

13. The international protocol to protect the ozone layer is the
(a) Montreal Protocol (b) Vienna Protocol
(c) Kyoto Protocol (d) Cartagena Protocol

14. Which of the following is not a greenhouse gas?
(a) Hydrochlorofluorcarbons (b) Methane
(c) Carbon dioxide (d) Oxygen

15. Global warming could affect
(a) climate (b) food production
(c) melting of glaciers (d) all of these

16. Which of the following is not a solution for global warming?
(a) Reducing fossil fuel consumption
(b) Planting more trees
(c) Deforestation
(d) None of the above

17. First of the major environmental protection Acts to be promulgated in India was
(a) the Water Act
(b) the Air Act
(c) the Environment Act
(d) Noise Pollution rules

18. Which of the following is not a responsibility of central pollution control board?
(a) Advise the Central Government on any matter concerning prevention and control of water and air pollution and improvement of the quality of air.
(b) Plan and execute a nationwide programme for the prevention, control or abatement of water and air pollution.
(c) Plan and organize training of persons engaged in programme on the prevention, control or abatement of water and air pollution.
(d) None of the above.

19. Chernobyl Nuclear Disaster occurred in the year

(a) 1984 (b) 1985

(c) 1986 (d) 1987

20. The precautionary principle was first introduced in

(a) The First International Conference on Protection of the North Sea

(b) The Earth Summit

(c) Vienna Convention

(d) Kyoto Protocol

Short-Answer Questions

1. Define the term *sustainable development*.

2. What are the major causes of concern about energy in India?

3. List the advantages of rainwater harvesting.

4. Classify the rainwater harvesting methods.

5. Define *watershed management*.

6. What are the objectives of watershed management?

7. Give examples of ethical issues frequently discussed in the subject Environmental Ethics.

8. What is acid rain?

9. How is the stratospheric ozone measured?

10. What is a Dobson unit?

11. List the major greenhouse gases and their sources.

12. List the major pollution control Acts in India.

13. What are the principal functions of central pollution control board?

14. Write short notes on the following:

(a) The Water (Prevention and Control of Pollution) Act, 1974

(b) The Air (Prevention and Control of Pollution) Act, 1981

(c) The Environment (Protection) Act, 1986

(d) The Wildlife Protection Act 1971

15. What are the objectives of environmental impact assessment?

16. Why is it necessary to involve the public in the process of EIA?

17. Cite a few historical examples of the application of the precautionary principle for environmental protection around the world.

Descriptive Questions

1. Explain the concept of sustainable development.
2. What are the major obstacles in the path of sustainable development in India?
3. Is it possible to sustain any developmental activity indefinitely? Explain your views.
4. Is it practically possible to have an infinitely sustainable development with the limited resources of earth and the ever-increasing per capita resource consumption? Discuss.
5. What are the major issues on Energy Utilization in Urban Planning?
6. Explain the role of renewable energy sources in achieving a sustainable energy base.
7. Give a brief account of ancient water conservation and harvesting practices in India.
8. Find out the rainwater harvesting methods currently being adopted in your locality and try to propose suggestions for improvement.
9. Suggest various methods for the improvement of irrigation efficiency by reducing loss due to evaporation.
10. Discuss the various water conservation techniques that can be practiced by individuals.
11. Explain the scope of the subject Environmental Ethics.
12. Explain the mechanism of formation of acid rain.
13. What are the causes and effects of acid rain?
14. Explain the acid rain and its impacts. How can we avoid it?
15. Explain the reactions leading to the formation and destruction of ozone in the stratosphere.
16. Explain the formation of Antarctic ozone hole and the role of polar stratospheric clouds (PSCs) in it.
17. Why is the ozone hole formation less severe in Arctic regions compared to Antarctica?
18. Write the plausible reactions responsible for the destruction of stratospheric ozone by CFCs.
19. As an individual what can you do to alleviate the ozone hole problem?
20. Explain the possible impacts of ozone depletion on the ecosystem.
21. Explain the phenomenon of global warming and the factors contributing to it.
22. Explain the possible impacts of global warming on the world's food supply.
23. What are the measures taken at the global level to control the emission of greenhouse gases?
24. Discuss the role of CPCB in the pollution control activities of India.
25. Discuss the constitutional provisions in India for environmental protection.

26. What are the major causes of nuclear hazards and accidents?

27. Discuss the ways to minimize radiation exposure in case of a nuclear accident.

28. List the different types of impact assessments possible.

29. Explain the key elements of EIA.

30. What are the possible monitoring mechanisms for the environmental impact of an engineering project?

31. What are the objectives of risk assessment in the case of engineering projects that are likely to affect the environment?

32. Explain the concept of precautionary principle.

33. Can you justify blocking development in the name of precautionary principle?

34. Compare and contrast polluter-pays principle with beneficiary-pays principle.

35. In a developing country like India, in your opinion, who should bear the expenses of environmental protection?

36. What are the possible avenues in which NGOs can contribute to the cause of environmental protection?

Answers to Objective-Type Questions

1. (d)	2. (d)	3. (c)	4. (b)	5. (b)	6. (d)	7. (b)
8. (b)	9. (d)	10. (b)	11. (d)	12. (b)	13. (a)	14. (d)
15. (d)	16. (c)	17. (a)	18. (d)	19. (c)	20. (a)	

HUMAN POPULATION AND THE ENVIRONMENT

"We cannot solve the problems that we have created with the same thinking that created them."

Albert Einstein

Learning Outcomes

On successful completion of this chapter, students will be able to:

- Demonstrate an understanding of the human growth patterns around the globe.
- Discuss and comment on the issues, Human Rights, Value Education, HIV/AIDS.
- Outline and discuss the topics Environment and Human Health and Family Welfare Programmes.

7.1 POPULATION GROWTH

Anthropologists believe the human species dates back at least 3 million years. For most of our history, our distant ancestors lived a precarious existence as hunters and gatherers.

This way of life kept their total numbers small, probably less than one crore (10 million). However, as agriculture was introduced, communities evolved that could support more people. World population expanded to about 30 crore (300 million) by A.D. 1 and continued to grow at a moderate rate. But after the beginning of the Industrial Revolution in the 18th century, living standards rose and widespread famines and epidemics diminished in some regions and population growth accelerated. The population climbed to about 76 crore (760 million) in 1750 and reached 100 crore (1 billion) around 1800 (see Table 7.1).

In 1800, the vast majority of the world's population (86%) resided in Asia and Europe, with 65% in Asia alone. By 1900, Europe's share of world population had risen to 25%, fuelled by the population increase that accompanied the Industrial Revolution. Some of this growth spilled over to the Americas, increasing their share of the world total.

In 2017, the world had 750 crore (7.5 billion) human inhabitants. This number could rise to more than 9 billion in the next 50 years. For the last 50 years, world population multiplied more rapidly than ever before, and more rapidly than it will ever grow in the future (see the projected world population in Fig. 7.1). A few terms frequently used while dealing with population growth are described below.

- *Birth rate* The number of live births per 1,000 population in a given year.
- *Growth rate* The number of persons added to (or subtracted from) a population in a year due to natural increase and net migration; expressed as a percentage of the population at the beginning of the time period.

Table 7.1 *History of Human Population Growth on Earth*

Year	*Human population*
10 000 BC (Agricultural revolution)	5–10 million
1 AD	170 million
1800 (Industrial revolution)	1 billion
1930	2 billion
1960	3 billion
1975	4 billion
1987	5 billion
1999	6 billion
2008	6.7 billion
2013	7.2 billion
2017	7.5 billion

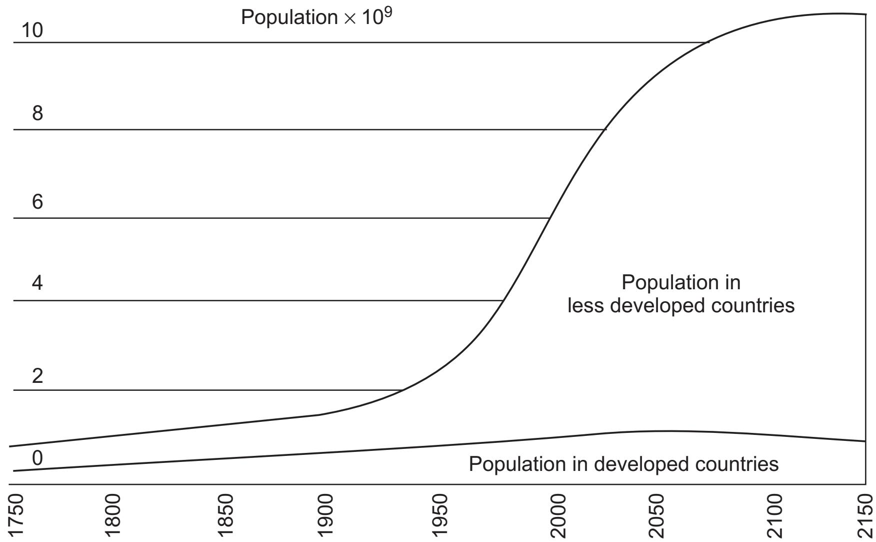

Fig. 7.1 *Projected World Population*

❑ *Doubling time* The number of years required for the population of an area to double its present size, given the current rate of population growth. Population doubling time is useful to demonstrate the long-term effect of a growth rate, but should not be used to project population size. Many less developed countries have high growth rates that are associated with short doubling times, but are expected to grow more slowly as birth rates are expected to continue to decline.

7.1.1 Population Variations among Nations

Improved medicine, sanitation, and nutrition have produced a major decline in death rates. This decline started in Europe and North America in the 1800s. Throughout the twentieth century, it has occurred in developing countries with astonishing speed. Between 1940 and 1960, falling death rates in Egypt caused average life expectancy to jump by twenty years.

Birth rates have also been falling, although not as quickly. Most Western countries now have such low birth rates that their populations are approaching stability or decline. Many developing countries have also achieved low birth rates, most notably in East Asia.

Elsewhere, notably in South Asia and Africa, birth rates remain quite high. Endemic poverty, low levels of education, and weak family planning programmes have kept the average number of children born to each woman over six. But even here, there has been some progress. Still, because these countries have a large proportion of young people, their populations will continue to grow rapidly for some time, even if these young people bear significantly fewer children than their parents.

During recent decades there has been a dramatic worldwide population increase. Based on current rates of increase of 1.5% per year, the world population is projected to double to more than 12 billion in about 46 years. The world population adds more than a quarter million people daily and this rapid growth is placing enormous pressure on the environment. The United States population doubled from 135 million to more than 270 million during the past 60 years and is projected to double again to 540 million in the next 70 years based on the current US growth rate of 1% per year. China's population is 1.2 billion and, despite the governmental policy of permitting only one child per couple, it is still growing at an annual rate of 1.1%.

India has nearly 1 billion people living on approximately one-third of the land of either the United States or China. India's current population growth rate is 1.9%, which translates to a doubling time of 37 years. Together, China and India constitute more than one-third of the total world population. Given the decline in resources, it is unlikely that India, China, and the world population in total will double.

7.1.2 Population Pyramids

The age-sex distribution of a population is an important feature to understand a country's demographic situation. These statistics give governments the tools they need to make informed decisions that will affect our lives today and in the future. One way to illustrate the structure of a population is to plot the number of males and females for various ages. Such a horizontal bar graph with data for males on the left and females on the right is called a population pyramid. A typical population pyramid for a developing country is shown in Fig. 7.2.

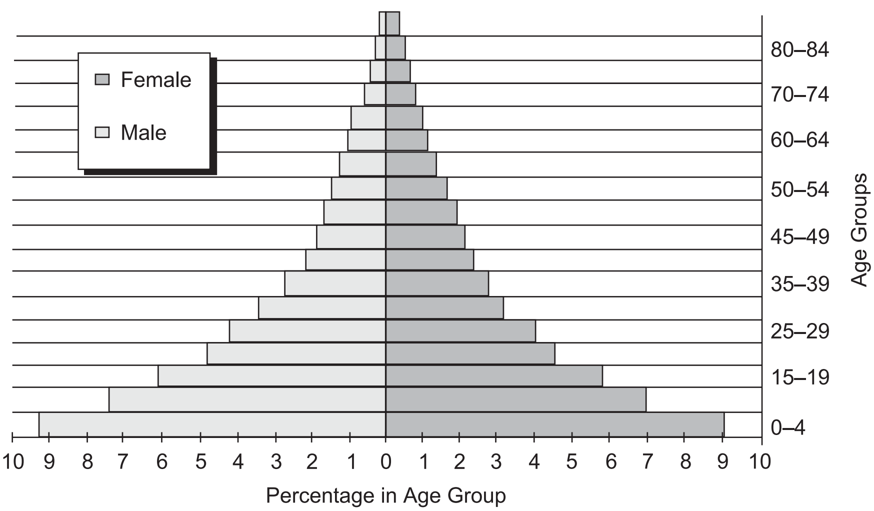

Fig. 7.2 *Typical Population Pyramid for a Developing Country*

During the last century, a sharp decline in premature mortality due to previously rampant infectious and chronic diseases has increased life expectancy. This has naturally led to an increase in the number of old people. At the same time, the invention and availability of modern contraceptive methods has caused a substantial fall in fertility. These two phenomena together contributed to population ageing. *Population ageing is the trend where more people live to reach old age while fewer children are born, resulting in an increase in the average age of the population of a country.* The main reasons for the ageing of society are socio-economic but better healthcare has improved survival for specific diseases. The existence of more old people and more survivors of serious diseases means an increase in the incidence of morbidity and non-life-threatening but disabling chronic diseases and conditions. As a society ages, there may come a time when there are not enough young people to finance or care the old. However, the actual cost of older people depends partly on the society in which they live. For example, an old man who lives with his family in a small village in an undeveloped country is likely to cost less than a retired executive in a developed country. A retired executive is likely to have accumulated sufficient wealth to provide for him to at least some extent in old age.

The increase in average life expectancy has led to the population of older people to grow at a rate of 2.8% per year worldwide. A parallel trend has been a reduction in fecundity and fertility and so the overall population growth (all ages) has been less, only 1.6% per year. The consequence is an ageing society, with a proportionately high (and increasing) number of older people.

7.1.3 Problems of Population Growth

Scientists worry that rapid population growth will overstress the earth's natural resources and crowd out undomesticated plant and animal species. All people want to be fed, clothed, housed, and have access to clean water. To meet these requirements, water, land, forests, and other natural resources must be exploited to some degree. As population increases, more resources are needed to meet basic requirements. More forest must be cut down to provide wood for housing and fuel. More cleared land is needed for agriculture and development. All of these resources are finite. More than 99% of the world's food supply comes from the land, while less than 1% is from oceans and other aquatic habitats. The continued production of an adequate food supply is directly dependent on ample fertile land, fresh water, energy, plus the maintenance of biodiversity. As the human population grows, the requirements for these resources also grow. Even if these resources are never depleted, on a per capita basis they will decline significantly because they must be divided among more people.

At the same time as people consume these resources, they produce waste that is put back into the air, land and water. The greater amount of waste from larger populations puts more stress on ecosystems. Even if markets function with perfect efficiency, and the best technology is always used, it will take more resources to support a larger population than a smaller one, and the environmental costs of doing so will probably be higher as well.

It is true that the highest population growth rates are found in developing countries. However, because affluent countries consume more resources, they remain the primary contributors to certain global environmental problems like global warming. The G7 nations, the US, Canada, Britain, France, Germany, Japan, and Italy represent only 10% of global population but consume over 40% of the earth's fossil fuels as well as most of the world's commodities and forest products. Because consumption rates are so high in these countries, even small increases in population can have a significant impact. The US, in particular, continues to have a higher rate of population growth than most of the other industrial countries, increasing the nation's environmental impact.

As the world population continues to grow geometrically, great pressure is being placed on arable land, water, energy and biological resources to provide an adequate supply of food while maintaining the integrity of our ecosystem. According to the World Bank and the UN, from 1–2 billion humans are now malnourished, indicating a combination of insufficient food, low incomes, and inadequate distribution of food. This is the largest number of hungry humans ever recorded in history. In China about 80 million are now malnourished and hungry. Based on current rates of increase, the world population is projected to double from roughly 6 billion to more than 12 billion in less than 50 years. As the world population expands, the food problem will become increasingly severe, conceivably with the numbers of malnourished reaching 3 billion.

Based on their evaluations of available natural resources, scientists of the Royal Society and the US National Academy of Sciences have issued a joint statement reinforcing the concern about the growing imbalance between the world's population and the resources that support human lives.

Reports from the FAO of the UN, numerous other international organizations, and scientific research also confirm the existence of this serious food problem. For example, the per capita availability of world grains, which make up 80% of the world's food, has been declining for the past 15 years. With a quarter million people being added to the world population each day, the need for grains and all other food will reach unprecedented levels.

Water is critical for all crops which require and transpire massive amounts of water during the growing season. For example, a hectare of corn will require more than 5 million liters of water during one growing season. This means that more than 8 million liters of water per hectare must reach the crop. In total, agricultural production consumes more fresh water than any other human activity. Specifically, about 87% of the world's fresh water is consumed or used up by agriculture and, thus, is not recoverable.

Competition for water resources among individuals, regions, and countries and associated human activities is already occurring with the current world population. About 40% of the world's people live in regions that directly compete for shared water resources. In China where more than 300 cities already are short of water, these shortages are intensifying. Worldwide, water shortages are reflected in the per capita decline in irrigation used for food production in all regions of the world during the past 20 years. Water resources, critical for irrigation, are under great stress as populous cities, states, and countries require and withdraw more water from rivers, lakes, and aquifers every year. A major threat to maintaining future water supplies is the continuing over-draft of surface and ground water resources.

Diseases associated with water rob people of health, nutrients, and livelihood. This problem is most serious in developing countries. For example, about 90% of the diseases occurring in developing countries result from lack of clean water. Worldwide, about 4 billion cases of disease are contracted from water and approximately 6 million deaths are caused by water-borne diseases each year. When a person is ill with diarrhea, malaria, or other serious disease, anywhere from 5–20% of an individual's food intake offsets the stress of the disease.

Fossil energy is another prime resource used for food production. Nearly 80% of the world's fossil energy used each year is used by the developed countries, and part of it is expended in producing high animal protein diets. The intensive farming technologies of developed countries use massive amounts of fossil energy for fertilizers, pesticides, irrigation, and for machines as a substitute for human labour. In developing countries, fossil energy has been used primarily for fertilizers and irrigation to help maintain yields rather than to reduce human labour inputs.

In general, developing countries have been relying heavily on fossil energy, especially for fertilizers and irrigation to augment their food supply. The current decline in per capita use of fossil energy, caused by the gradual decline in oil supplies and their relatively high prices, is generating direct competition between developed and developing countries for fossil energy resources.

In addition, we must keep in mind that the environmental, population, and economic problems of developing countries often have global effects. It is in the interest of industrial nations to help poorer countries to pursue comprehensive development efforts to reduce poverty and lower birth rates. Moreover, because many technologies and consumption patterns that originate in industrial nations spread to the rest of the world, these countries have a responsibility to develop environmental-friendly technologies and sustainable consumption patterns.

CASE STUDY

China's Gender Imbalance Stems from 'Family Planning' Policy

The ratio of baby girls to baby boys in China has dropped further below the international standard—the result, critics say, of its controversial "one-child policy," which in some cases has led to sex-selective abortion, infanticide and the abandonment of baby girls.

In the 1980s, China launched a programme aimed at slowing its ever increasing population growth, by discouraging parents from having more than one child, using both incentives and penalties to enforce the policy. Many rural peasants, who make up the majority of the population, are anxious to have a son to help support them in their old age, particularly in the absence of a social security scheme. Boys are also traditionally favoured. The rules were relaxed somewhat for rural people (who may have a second child if their first born is a girl, but not a third) yet the problems persist. Human rights monitors say the gender imbalance is partly attributable to incomplete population statistics, as families sometimes avoid reporting the birth of a daughter so they continue trying for a son. Although the practice is illegal, some Chinese parents abort baby girls after ascertaining their gender during an ultrasound scan. In 2016, the Chinese Government formally abolished the one-child policy, replacing it with a two-child policy to tackle population ageing and gender imbalance.

CASE STUDY

Abortion Cuts Russian Birth Rate to Critical Levels

With only one pregnancy in three carried to term because of the prevalence of abortions, Russia's birth rate has fallen to critical levels, women of child bearing age are having an average of 1.3 children each, lower than the normal level of 2.3 and closer to the critical floor of 1.1. In the 1990s, Russia's population had decreased by close to 2% with 2.8 million fewer people, according to official figures. Deaths far outpace births by a ratio of 14.7 in 1,000 compared to 8.4. Only 1.2 million children are born each year in Russia, well below the 2 million needed to keep the population at existing levels.

CASE STUDY

Singapore Set to Relax Rules to Boost Population (2004)

Singapore will grant more foreign born children citizenship, hoping to boost a rapidly ageing population. Babies born abroad to Singaporean women married to foreigners will have the right to citizenship. Singapore's birth rate is below the 2.1 children per woman needed to replenish its stock. Baby making has become a priority in Singapore, where women gave birth to 1.26 babies, on an average, in 2003 the lowest in the nation's history. The proportion of childless couples has tripled since 1980 to 6%. This is the most dramatic step since the baby shortage debate in 2004. A committee was formed to consider maternity leave, tax benefits for families and subsidising infant care. Future generations of Singaporeans living abroad can pass on citizenship as long as mothers or fathers spend five years in the country before having a baby. The number of people over 65 is forecast to grow fourfold to 800 000 by 2030 with no growth in the working age population to support them. If the trend continues, by 2030, 8% of Singapore's population will be 15–24, putting strain on young Singaporeans to support the economy and its ageing workforce.

CASE STUDY

Polish Demographers Worried by Declining Population

The Polish Government is preparing a programme to prevent the decline. Today if the assumptions do not change and married couples and the population in Poland are going to carry on until 2030 as has been assumed, the population is going to decline by 2.5 million. The situation will unfavourably affect the country's development. It will cause a deterioration in the ratio of those in employment and those living from old-age and disability pensions. More children have to be born. The causes of the low birth rate are problems with employment and lack of housing. But the demographers hope that programme to be created will slow down or reverse the trends.

CASE STUDY

Implications of Ageing Nation

In China, adults who are 60 and over form 11% of the population. By 2040, this will rise to 28%, 397 million people. Per capita income is one-fifth of S. Korea and one-ninth the US. China is trying to raise living standards while its population is young and growing as in the long term, it has to care for a larger number of dependent elderly people. The solution may be to combine a pay-as-you-go floor of protection with mandatory funded personal retirement accounts. The existing system covers only a fraction of the population and the State-owned sector is running into financial trouble. Millions of

(*Contd.*)

Chinese reaching old age over the next half century will have no pension or health care coverage. Pension coverage is largely limited to urban workers in the State-owned sector. In 2002, the basic pension covered mainly employees at State owned enterprises. The government has begun to extend pension coverage to the private sector but participation is minimal. A system for civil servants covers 10% of the urban workforce. Rural workers are excluded although 11% participate in a voluntary pension system. Only 25% of China's workforce have any pension provision. Government health insurance is limited to the same groups, although coverage rates are higher than for pensions. The cost is a modest share of the economy, about 3.5% on public pensions, and 0.5% on health care benefits for retirees. Although retirement benefits consume a small share of China's economy, they are a burden on workers and employers. High contribution rates are leading to evasion in the pension system and deficits that the government must cover. In rural China, workers count on the extended family for support in old age. For Chinese without public retirement benefits, the alternative is limited. As China modernizes, its old-age support is coming under stress. The exodus of young adults from the countryside is separating elderly people in rural areas from their children. In the cities, urban elderly are being stripped of their traditional role. China is beginning to confront its ageing challenge and the need to build a more inclusive and affordable retirement system. Starting in the 1990s, it began to expand the basic pension system to include the urban private sector. At the same time, it is implementing a plan to shift from a pay-as-you-go system, in which current workers are taxed to pay for current retirees, to a two-tiered system of scaled-back pay-as-you-go benefits and personal retirement accounts. Private enterprises have little incentive to join the new system, whose contributions go to pay off the unfunded liabilities of the old system. As of 2002, more than 90% of private sector workers had no pension coverage. The personal accounts, administered by municipal and provincial social security bureaus, are not being saved and invested. Worker contributions are treated as tax revenue and used to cover the deficit in the system's pay-as-you-go. To ensure that coverage under the new system is affordable, the government must assume the old system's liabilities. To ensure that personal accounts are funded, it will need to transfer management from the social security bureaus to independent managers. It will have to build an old age safety net in the countryside. To win participants' trust, the government must ensure the security and transparency of the personal accounts. Despite their growth, China's stock markets remain small and illiquid. The lack of liquidity breeds a speculative investment culture. Chinese firms have little experience in managing pension assets. The participation of foreign financial services will be crucial. Without an effective retirement policy, it is hard to envision a prosperous and peaceful future for China. China needs to raise capital from the savings of working families who today often invest in unproductive housing or deposit it in banks. If China's current personal accounts system were extended to the entire urban workforce, total contributions this year would come to about 250 billion yuan (US $ 30.2 billion). Even a small fraction of this would constitute a substantial inflow of capital. Personal accounts will educate workers about financial markets. If China is successful, not only will elderly people retire in greater comfort and families live with fewer worries, it will also be a future in which capital formation is stronger, living standards are higher, and public trust in government is even firmer.

CASE STUDY

Australia's Aged Population is Increasing

Australia is underestimating the future number of people over 85. The forecast for 2031 is 660 000, but should be 845 000—a difference of 180 000. This could mean supporting older citizens in 20 to 40 years than the government has provided for. Some hard decisions need to be made about the funding of services for the aged over the next 20 years. Mortality and fertility do not fall or rise smoothly. In the late 1980s the mortality rate for people between 18 and 25 increased due to AIDS, suicides and road deaths but has now started dropping. For the first time we can put probability limits around the population for different ages and rate how certain we are that it will be correct. This methodology could supply vital information to determine the future cost of pensions. The Federal Treasury is running the new methodology with their existing methodology to compare them. The forecasting has been used successfully to predict budgetary requirements for the Pharmaceutical Benefits Scheme and has developed commercial software for automatic forecasting that is sold in Australia and overseas.

CASE STUDY

Canada: Education, Migration, Divorce Cause, Fall in Birth Rate

Canada's birth rate fell to 10.5 births for every 1,000 people, down by 25% in the last decade of 20th century. Women are having the same 1.5 babies that they've been having for the past 10 years but there are fewer women in the fertile age group 25 to 30. Experts point to an array of factors, including increasing education for women, the urbanization of society and the breakdown in family units. Where a new generation was born every 20 years, it's now closer to 30. When you increase the time between generations, there will be fewer children. All agree that the fertility rate has seen a decline over the last 40 years. One factor is higher education that has given women career opportunities that caused women to delay pregnancies until their careers have been established. Education has also given women better knowledge about birth control products. The move to urban living has an effect as agrarian societies, babies are viewed as a source of future labour supply but in urban settings, children are more likely to be economic drains on their parents. Urban parents rely on pension plans, rather than their children. Many working class women are putting off children because they simply can't afford to support them. Family change, such as divorce, cohabitation and looseness of relationships, comes with fewer children because there's less security.

7.2 HUMAN RIGHTS

Human rights are the rights a person has, simply because he or she is a human being. Human rights are held by all persons equally, universally, and forever. Human rights are inalienable and thus cannot be taken away from a person under any circumstances. You cannot lose these rights any more than you can cease being a human being. Human rights are considered as the basic standards without which people cannot live in dignity. To violate someone's human rights is to treat that person as though he or she were not a human being. To advocate human rights is to demand that the human dignity of all people be respected. Thus, human rights are universal legal guarantees protecting individuals and groups against actions which interfere with fundamental freedoms and human dignity. Some of the most important characteristics of human rights are the following.

- Human rights are guaranteed by international standards and are legally protected.
- Human rights focus on dignity of human beings.
- Human rights are indivisible and hence one cannot be denied, waived or taken away.
- Human rights are interdependent; all human rights are part of a complementary framework. For example, our ability to participate in our government is directly affected by our right to express ourselves, to get an education, and even to obtain the necessities of life.
- Human rights are interrelated; and universal.

7.2.1 Human Rights as Inspiration and Empowerment

Human rights are both inspirational and practical. Human rights principles hold up the vision of a free, just, and peaceful world and set minimum standards for how individuals and institutions everywhere should treat people. Human rights also empower people with a framework for action when those minimum standards are not met, for people still have human rights even if the laws or those in power do not recognize or protect them.

We experience our human rights every day in India, when we worship according to our belief, or choose not to worship at all; when we debate and criticize government policies; when we join a trade union; when we travel to other parts of the country or overseas. Although we usually take these actions for granted, people both here and in other countries do not enjoy all these liberties equally. Human rights violations also occur every day in this country when a parent abuses a child, when a family is homeless, when a school provides inadequate education, when women are paid less than men, or when one person steals from another.

7.2.2 Human Right Act, 1993

This is an Act to provide for the constitution of a National Human Rights Commission, State human rights commissions in states and human rights courts for better protection of human rights and for matters connected therewith or incidental thereto.

Continuous attempts are being made by the Commission to address various Human Rights Issues. Some of these issues are being monitored as Programmes on the directions of the Supreme Court. The following is a list of typical human right issues monitored as programmes by the national human rights commission in India.

- Abolition of bonded labour
- Right to food
- Review of the Child Marriage Restraint Act, 1929
- Protocols to the convention on the Rights of the Child
- Abolition of child labour
- Guidebook for the media on sexual violence against children
- Trafficking in women and children: manual for the Judiciary for gender sensitization
- Sensitization programme on prevention of sex tourism and trafficking
- Combating sexual harassment of women at the workplace
- Harassment of women passengers in trains
- Abolition of manual scavenging
- Rights of the disabled

On December 10, 1948 the General Assembly of the UN adopted and proclaimed the Universal Declaration of Human Rights. Following this historic act the Assembly called upon all Member countries to publicize the text of the Declaration and "to cause it to be disseminated, displayed, read and expounded principally in schools and other educational institutions, without distinction based on the political status of countries or territories." Recognition of the inherent dignity and of the equal and inalienable rights of all members of the human family is the foundation of freedom, justice and peace in the world. Disregard and contempt for human rights have resulted in barbarous acts which have outraged the conscience of mankind, and the advent of a world in which human beings shall enjoy freedom of speech and belief and freedom from fear and want has been proclaimed as the highest aspiration of the common people. It is essential, if man is not to be compelled to have recourse, as a last resort, to rebellion against tyranny and oppression, that human rights should be protected by the rule of law. It is essential to promote the development of friendly relations between nations. The people of the UN have in the Charter reaffirmed their faith in fundamental human rights, in the dignity and worth of the human person and in the equal rights of men and women and have determined to promote social progress and better standards of life in larger freedom. Member States have pledged themselves to achieve, in co-operation with the UN, the promotion of universal respect for and observance of human rights and fundamental freedoms. A common understanding of these rights and freedoms is of the greatest importance for the full realization of this pledge. Therefore the general assembly proclaims this universal declaration of human rights as a common standard of achievement for all peoples and all nations, to the end that every individual and every organ of society, keeping this Declaration constantly in mind, shall strive by teaching and education to promote respect for these rights and freedoms and by progressive measures, national and international to secure their universal and effective recognition and observance, both among the peoples of Member States themselves and among the peoples of territories under their jurisdiction.

Article 1

All human beings are born free and equal in dignity and rights. They are endowed with reason and conscience and should act towards one another in a spirit of brotherhood.

Article 2

Everyone is entitled to all the rights and freedoms set forth in this Declaration, without distinction of any kind, such as race, colour, sex, language, religion, political or other opinion, national or social origin, property, birth or other status. Furthermore, no distinction shall be made on the basis of the political, jurisdictional or international status of the country or territory to which a person belongs, whether it be independent, trust, non-self-governing or under any other limitation of sovereignty.

Article 3

Everyone has the right to life, liberty and security of person.

Article 4

No one shall be held in slavery or servitude; slavery and the slave trade shall be prohibited in all their forms.

Article 5

No one shall be subjected to torture or to cruel, inhuman or degrading treatment or punishment.

Article 6

Everyone has the right to recognition everywhere as a person before the law.

Article 7

All are equal before the law and are entitled without any discrimination to equal protection of the law. All are entitled to equal protection against any discrimination in violation of this Declaration and against any incitement to such discrimination.

Article 8

Everyone has the right to an effective remedy by the competent national tribunals for acts violating the fundamental rights granted him by the constitution or by law.

Article 9

No one shall be subjected to arbitrary arrest, detention or exile.

Article 10

Everyone is entitled in full equality to a fair and public hearing by an independent and impartial tribunal, in the determination of his rights and obligations and of any criminal charge against him.

Article 11

(1) Everyone charged with a penal offence has the right to be presumed innocent until proved guilty according to law in a public trial at which he has had all the guarantees necessary for his defense.

(2) No one shall be held guilty of any penal offence on account of any act or omission which did not constitute a penal offence, under national or international law, at the time when it was committed. Nor shall a heavier penalty be imposed than the one that was applicable at the time the penal offence was committed.

Article 12

No one shall be subjected to arbitrary interference with his privacy, family, home or correspondence, nor to attacks upon his honour and reputation. Everyone has the right to the protection of the law against such interference or attacks.

Article 13

(1) Everyone has the right to freedom of movement and residence within the borders of each state.

(2) Everyone has the right to leave any country, including his own, and to return to his country.

Article 14

(1) Everyone has the right to seek and to enjoy in other countries asylum from persecution.

(2) This right may not be invoked in the case of prosecutions genuinely arising from non-political crimes or from acts contrary to the purposes and principles of the UN.

Article 15

(1) Everyone has the right to a nationality.

(2) No one shall be arbitrarily deprived of his nationality nor denied the right to change his nationality.

Article 16

(1) Men and women of full age, without any limitation due to race, nationality or religion, have the right to marry and to found a family. They are entitled to equal rights as to marriage, during marriage and at its dissolution.

(2) Marriage shall be entered into only with the free and full consent of the intending spouses.

(3) The family is the natural and fundamental group unit of society and is entitled to protection by society and the State.

Article 17

(1) Everyone has the right to own property alone as well as in association with others.

(2) No one shall be arbitrarily deprived of his property.

Article 18

Everyone has the right to freedom of thought, conscience and religion; this right includes freedom to change his religion or belief, and freedom, either alone or in community with others and in public or private, to manifest his religion or belief in teaching, practice, worship and observance.

Article 19

Everyone has the right to freedom of opinion and expression; this right includes freedom to hold opinions without interference and to seek, receive and impart information and ideas through any media and regardless of frontiers.

Article 20

(1) Everyone has the right to freedom of peaceful assembly and association.

(2) No one may be compelled to belong to an association.

Article 21

(1) Everyone has the right to take part in the government of his country, directly or through freely chosen representatives.

(2) Everyone has the right of equal access to public service in his country.

(3) The will of the people shall be the basis of the authority of government; this will shall be expressed in periodic and genuine elections which shall be by universal and equal suffrage and shall be held by secret vote or by equivalent free voting procedures.

Article 22

Everyone, as a member of society, has the right to social security and is entitled to realization, through national effort and international co-operation and in accordance with the organization and resources of each State, of the economic, social and cultural rights indispensable for his dignity and the free development of his personality.

Article 23

(1) Everyone has the right to work, to free choice of employment, to just and favourable conditions of work and to protection against unemployment.

(2) Everyone, without any discrimination, has the right to equal pay for equal work.

(3) Everyone who works has the right to just and favourable remuneration ensuring for himself and his family an existence worthy of human dignity, and supplemented, if necessary, by other means of social protection.

(4) Everyone has the right to form and to join trade unions for the protection of his interests.

Article 24

Everyone has the right to rest and leisure, including reasonable limitation of working hours and periodic holidays with pay.

Article 25

(1) Everyone has the right to a standard of living adequate for the health and well being of himself and of his family, including food, clothing, housing and medical care and necessary social services, and the right to security in the event of unemployment, sickness, disability, widowhood, old age or other lack of livelihood in circumstances beyond his control.

(2) Motherhood and childhood are entitled to special care and assistance. All children, whether born in or out of wedlock, shall enjoy the same social protection.

Article 26

(1) Everyone has the right to education. Education shall be free, at least in the elementary and fundamental stages. Elementary education shall be compulsory. Technical and professional education shall be made generally available and higher education shall be equally accessible to all on the basis of merit.

(2) Education shall be directed to the full development of the human personality and to the strengthening of respect for human rights and fundamental freedoms. It shall promote understanding, tolerance and friendship among all nations, racial or religious groups, and shall further the activities of the UN for the maintenance of peace.

(3) Parents have a prior right to choose the kind of education that shall be given to their children.

Article 27

(1) Everyone has the right freely to participate in the cultural life of the community, to enjoy the arts and to share in scientific advancement and its benefits.

(2) Everyone has the right to the protection of the moral and material interests resulting from any scientific, literary or artistic production of which he is the author.

Article 28

Everyone is entitled to a social and international order in which the rights and freedoms set forth in this Declaration can be fully realized.

Article 29

(1) Everyone has duties to the community in which alone the free and full development of his personality is possible.

(2) In the exercise of his rights and freedoms, everyone shall be subject only to such limitations as are determined by law solely for the purpose of securing due recognition and respect for the rights and freedoms of others and of meeting the just requirements of morality, public order and the general welfare in a democratic society.

(3) These rights and freedoms may in no case be exercised contrary to the purposes and principles of the United Nations.

Article 30

Nothing in this Declaration may be interpreted as implying for any State, group or person any right to engage in any activity or to perform any act aimed at the destruction of any of the rights and freedoms set forth herein.

7.2.3 Amnesty International

Amnesty International (AI) is a worldwide movement of people who campaign for internationally recognized human rights. AI's vision is of a world in which every person enjoys all of the human rights enshrined in the Universal Declaration of Human Rights and other international human rights standards. In pursuit of this vision, AI's mission is to undertake research and action focused on preventing and ending grave abuses of the rights to physical and mental integrity, freedom of conscience and expression, and freedom from discrimination, within the context of its work to promote all human rights.

AI is independent of any government, political ideology, economic interest or religion. It does not support or oppose any government or political system, nor does it support or oppose the views of the victims whose rights it seeks to protect. It is concerned solely with the impartial protection of human rights.

AI has a varied network of members and supporters from over 150 countries and every region of the world. Although they come from many different backgrounds and have widely different political and religious beliefs, they are united by a determination to work for a world where everyone enjoys human rights. AI is a democratic, self-governing movement. Major policy decisions are taken by an International Council made up of representatives from all national sections. AI's national sections and local volunteer groups are primarily responsible for funding the movement. No funds are sought or accepted from governments for AI's work investigating and campaigning against human rights violations.

7.3 VALUE EDUCATION

Values are not only with beliefs but also with our understanding, feelings and behaviour. Value education may be understood in a broad sense to mean all aspects of the process by which teachers transmit values to the students.

Ancient Indian education had always given importance to value components. The education up to eighteenth century involved study of scriptures and Upanishads which are essentially the discourses on morality, ethics and virtuosity. The value education was the pivotal concern around which other knowledge areas were developed. Later the influences of cultures from across the boundaries and British colonization brought about changes in the structure of society. The urban living replaced village symbiotic existence, joint family gave way to micro family and consequent changes sneaked into the educational system also. Apart from these developments, simultaneously growing influence of science and technology and consequent industrialization led to efforts aimed at strengthening of the education system by increasing inputs on science and technology. The efforts were successful. Green revolution, white revolution, self-sufficiency in steel production, etc. and now spearheading the information technology are the supporting evidence. However, in this process of modernization of education, the emphasis shifted to economic and secular values. The education system lost its role as guardian of ethical and moral values. The efforts are continuing to reconstruct education to fulfil its role in preservation of the moral character of the society and to keep pace with the economic and technological developments.

Concerns felt in all echelons of the education system, about its role in promoting universal human values have resulted in affirmative action in this regard. The Report of Parliamentary Standing Committee, on Human Resource Development, submitted to the

Rajya Sabha and also laid on to the table of Lok Sabha has emphasized Value Education. NCERT, being the apex organization in the area of school education, has been identified as the National Resource Centre for Value Education with a view to promoting value orientation of school education at all levels, elementary, secondary, senior secondary. A core group on value education has been formed for the centre. Value-based education has come to center-stage in recent efforts of the Government of India to reorient the education system. The National Resource Centre for Value Education (NRCVE) was set up at NCERT as an outcome of strategic planning to realize the objectives of value-based education at school stage in the country. The action towards setting up the Centre began in September 1999. The goals and functions of the Centre are to:

- Develop plans, programmes, and activities for value-orientation of school education;
- Design strategies for implementing the plans and programmers;
- Develop educational materials and other teaching aids;
- Document and disseminate information;
- Provide extension and consultancy services;
- Serve as a treasure house cum reference library of educational materials.

Realization of these goal and functions is the joint venture of different constituents of the NCERT including the Regional Institutes of Education, Central Institute of Educational Technology and Pandit Sunder Lal Sharma Central Institute of Vocational Education.

The values that can make human life valuable, elevated, successful and beneficial are the life values. These values were born with humanity itself and are eternal, immortal and ever-lasting. The major objective of value education is to include good values as an individual to lead a life as a responsible future citizen of India having a feeling of universal brotherhood. The role of the teacher is very crucial in the process of value education. If the teacher performs these roles with his heart and soul in it, he will automatically be responsible for the effective implementation of value education. Considering the above mentioned need, the training of teachers in this direction becomes very essential.

7.4 HIV/AIDS

HIV stands for Human Immunodeficiency Virus, the virus that causes AIDS. AIDS is a result of the HIV virus. It is not a disease but a weakness in the body that results in the body being unable to fight off illnesses. The immune system of a person with AIDS is weakened to such a point that medical intervention is necessary to prevent or treat the deterioration in the body and the entire system. AIDS is the most serious stage of HIV infection. It results from the destruction of the infected person's immune system.

Our immune system is our body's defense system. Cells of our immune system fight off infection and other diseases. If the immune system does not work well, we are at risk for serious and life-threatening infections and cancers. HIV attacks and destroys the disease-fighting cells of the immune system, leaving the body with a weakened defense against infection and cancer.

7.4.1 Process of Infection

The AIDS virus causes a weakness of the immune system. When it infects the body, it prefers to attack certain cells of our defense system. These cells are called helper T cells which are a fundamental part of our immune system. The AIDS virus almost fully specializes on these white blood cells since these helper T cells have CD4 molecules on the surface to which the AIDS virus binds. The AIDS virus, to put it simply, consists of genetic information on the inside and a protective outer shell of proteins and glycoproteins. Since viruses use the host cell's resources for reproduction, they don't need to contribute much themselves. That's why they are much smaller than the host cells, e.g. helper T cells. In the host cell's nucleus, there are more than 100 000 times as much genetic information stored than under the protein shell of the AIDS virus. However, there is no way for the host cell to stop the virus, once the cell has been infected. The infection proceeds in this manner: The virus anchors itself to a special protein (CD4) on the surface of the helper T cell. This causes the viral membrane to fuse with the host cell's membrane. This way the genetic information gets inside the cell. The AIDS virus belongs to a special group of viruses. Its genetic information is not encoded as DNA, but instead as RNA (Ribonucleic Acid) and therefore has to be reverse transcripted into DNA. The tools for this are delivered by the host cell itself, except for a little helper protein (reverse transcriptase) which the virus has brought with itself. The DNA is now legible for the cell and is transferred to the nucleus. This process is already finished by a half of a day after infection. The foreign piece of DNA is then inserted randomly into the host DNA and it is now ready to be transcribed. At the beginning of AIDS, the viral DNA is being transcribed to form many RNA molecules (the signal which causes this is yet unknown). The accruing RNA is carried to the cytoplasm of the cell, where it can start making proteins. The RNA, with the help of the host's resources, begins to make many copies of the different parts of the AIDS virus (the protective shell and the helper and anchor proteins). After everything has been copied, thousands of bubbles like these are produced and migrate to the cell membrane surface and fuse with it. Finally, a copy of the RNA genetic information is added to the bubble. Then this section of the cell membrane turns inside out and new viruses leave the cell. Naturally, the release of the new AIDS viruses significantly weakens the host cell which soon dies. This is how the immune system weakens and AIDS starts.

7.4.2 HIV Test

The only way to know if you are infected is to be tested for HIV infection. You cannot rely on symptoms to know whether or not you are infected with HIV. Many people who are infected with HIV do not have any symptoms at all for many years.

The following may be warning signs of infection with HIV:

- Rapid weight loss
- Dry cough
- Recurring fever or profuse night sweats
- Profound and unexplained fatigue
- Swollen lymph glands in the armpits, groin, or neck
- Diarrhea that lasts for more than a week
- White spots or unusual blemishes on the tongue, in the mouth, or in the throat
- Pneumonia
- Red, brown, pink, or purplish blotches on or under the skin or inside the mouth, nose, or eyelids
- Memory loss, depression, and other neurological disorders

However, no one should assume they are infected if they have any of these symptoms. Each of these symptoms can be related to other illnesses. Again, the only way to determine whether you are infected is to be tested for HIV infection.

Similarly, you cannot rely on symptoms to establish that a person has AIDS. The symptoms of AIDS are similar to the symptoms of many other illnesses. AIDS is a medical diagnosis made by a doctor based on specific criteria established.

7.4.3 Transmission of HIV

HIV transmission can occur when body fluids of an infected person enters the body of an uninfected person. HIV can enter the body through a vein (e.g. injection' drug use), the anus or rectum, the vagina, the penis, the mouth, other mucous membranes (e.g. eyes or inside of the nose), or cuts and sores. Intact, healthy skin is an excellent barrier against

HIV and other viruses and bacteria. The following are the most common ways that HIV is transmitted from one person to another:

- By having sexual intercourse with an HIV-infected person;
- By sharing needles or injection equipment with an injection drug user who is infected with HIV;
- From HIV-infected women to babies before or during birth, or through breast-feeding after birth;
- HIV can also be transmitted through transfusions of infected blood or blood clotting factors;
- Some healthcare workers have become infected after being stuck with needles containing HIV-infected blood or, less frequently, after infected blood contact with the worker's open cut or through splashes into the worker's eyes or inside his or her nose.

7.4.4 Survival of HIV Outside the Body

Scientists and medical authorities agree that HIV does not survive well outside the body, making the possibility of environmental transmission remote. HIV is found in varying concentrations or amounts in blood, semen, vaginal fluid, breast milk, saliva, and tears. To obtain data on the survival of HIV, laboratory studies have required the use of artificially high concentrations of laboratory-grown virus. Although these unnatural concentrations of HIV can be kept alive for days or even weeks under precisely controlled and limited laboratory conditions, studies have shown that drying of even these high concentrations of HIV reduces the amount of infectious virus by 90 to 99% within several hours. Since the HIV concentrations used in laboratory studies are much higher than those actually found in blood or other specimens, drying of HIV-infected human blood or other body fluids reduces the theoretical risk of environmental transmission to that which has been observed essentially zero. Incorrect interpretations of conclusions drawn from laboratory studies have in some instances caused unnecessary alarm.

7.4.5 HIV and AIDS in India

India had a sharp increase in the estimated number of HIV infections, from a few thousand in the early 1990s to a working estimate of between 3.8 million and 4.6 million children and adults living with HIV/AIDS in 2002. However, last decade has seen considerable reduction in new HIV infections and by 2015 the number of people living with HIV in India has come down to 2.81 million.

7.5 ENVIRONMENT AND HUMAN HEALTH

If you suffer from chronic headaches, migraines, asthma, allergies, chronic sinus stuffiness, joint pain, chronic fatigue, or any of a number of other vague symptoms and your doctor cannot find a medical cause, your environment may be the culprit. Homes, schools, workplaces, and shopping centers virtually any indoor environment can harbour chemical and biological pollutants that can lead to chronic health complaints. Understanding your environment and the factors that can lead to symptoms can be your first step towards living a healthier life.

7.5.1 A History of Pandemics

Pandemics emerge out of social and environmental conditions, and they can induce changes in both of them. At times the resulting changes have been disruptive; in other instances they have stimulated significant social reform.

A pandemic, of debated cause but remembered as the Plague of Justinian, struck Europe in AD 541. It came as the Roman Empire was in decline, and it raged for two centuries, claiming over 40 million lives, in an era when the total population of the Earth was at most 300 million. Urban centers were abandoned and the plague helped to drive population resettlement into rural, feudal communities before it disappeared.

7.6 FAMILY WELFARE PROGRAMMES

India launched the National Family Welfare Programme in 1951 with the objective of "reducing the birth rate to the extent necessary to stabilise the population at a level consistent with the requirement of the National economy".

The Family Welfare Programme in India is recognized as a priority area, and is being implemented as a 100% centrally-sponsored programme. As per the Constitution of India, Family Planning is in the Concurrent list. The approach under the programme during the First and Second Five Year Plans was mainly "Clinical" under which facilities for provision of services were created. However, on the basis of data brought out by the 1961 census, clinical approach adopted in the first two plans was replaced by "Extension and Education Approach" which envisaged expansion of services facilities along with spread of message of small family norm.

7.7 WOMEN AND CHILD WELFARE

The Department of Women and Child Development was set up in the year 1985 as a part of the Ministry of Human Resource Development to give the much needed impetus to the holistic development of women and children. As the national machinery for the advancement of women and children, the Department formulates plans, policies and programmes; enacts/amends legislation, guides and coordinates the efforts of both governmental and non-governmental organizations working in the field of Women and Child Development.

The major policy initiatives undertaken by the Department of Women and Child development in the recent past include the following:

- establishment of the National Commission for Women (NCW),
- Rashtriya Mahila Kosh (RMK),
- adoption of National Nutrition Policy (NNP),
- universalising and strengthening of ICDS,
- setting up of National Creche Fund (NCF),
- launching of Indira Mahila Yojana (IMY),
- launching of Balika Samriddhi Yojana (BSY),
- launching of Rural Women's Development and Empowerment Project (RWDEP).

7.7.1 Subjects Allocated to the Department

Women and Child Welfare and Coordination of activities of other ministries and organizations in connection with this subject.

- Care of pre-school children
- Coordination of National Nutrition Education of Women
- Charitable and religious endowments pertaining to subjects allocated to this Department
- Promotion and development of voluntary effort on the subjects allocated to this Department
- All other attached or subordinate offices or other organizations concerned with any of the subjects specified in this list
- Administration of the Suppression of Immoral Traffic in Women and Girl Act 1956 (104 of 1956)

- The Dowry Prohibition Act, 1961 (28 of 1961)
- Coordination of activities of Cooperative American Relief Everywhere (CARE)
- Planning, Research, Evaluation, Monitoring, Project formulation, Statistics and Training relating to the Development of Women and Children
- References from the United Nations Organizations relating to traffic in Women and Children
- United Nations Children's Fund (UNICEF)
- Central Social Welfare Board (CSWB)
- National Institute of Public Cooperation and Child Development (NIPCCD)
- National Commission for Women (NCW)
- Food and Nutrition Board (FNB)
- Rashtriya Mahila Kosh (RMK)
- National Nutrition Policy (NNP)
- Indira Mahila Yojana (IMY)
- Balika Samriddhi Yojana (BSY)

7.7.2 Child Development

As per 2011 Census, India has around 112 million children, constituting 9.3% of India's population, who are below the age of 5 years. A large number of them live in economic and social environment which impede the child's physical and mental development. The programme of the Integrated Child Development Services (ICDS) was launched in 1975 seeking to provide an integrated package of services in a convergent manner for the holistic development of the child.

- To raise the health and nutritional level of poor Indian children below 6 years of age
- To create a base for proper mental, physical and social development of children in India
- To reduce instances of mortality, malnutrition and school dropouts among Indian children
- To coordinate activities of policy formulation and implementation among all departments of various ministries involved in the different government programmes and schemes aimed at child development across India
- To provide health and nutritional information and education to mothers of young children to enhance child rearing capabilities of mothers in India

- To provide nutritional food to the mothers of young children and also at the time of pregnancy

The following services are sponsored under ICDS to help achieve its objectives.

- Immunization
- Supplementary nutrition
- Health checkup
- Referral services
- Pre-school nonformal education
- Nutrition and health information

7.8 ROLE OF INFORMATION TECHNOLOGY IN ENVIRONMENT AND HUMAN HEALTH

The following is a representative list of applications of information technology in environment and human health.

- Environmental pollution (e.g. Ground water pollution, Marine pollution, Forest destruction, etc.) monitoring using remote sensing and Geographical Information Systems (GIS).
- Enabling environmental scientists and decision makers around the world to communicate, collaborate, and coordinate.
- Tracking and study of wildlife with remote monitoring using technologies such as radio collars.
- Computer based modeling and simulation of environmental scenarios for analysis and prediction.
- Telemedicine and advanced diagnostic equipments to care for human health.

BURNING TOPIC

Sustainable Development Goals (SDGs)

Sustainable Development Goals is a set of 17 global goals set by United Nations to be attained by 2030.

Fig. 7.3 *Sustainable Development Goals*

REVIEW QUESTIONS

Objective-Type Questions

1. The major cause of global population growth in the 18th and 19th centuries was

(a) decrease in death rates
(b) decrease in birth rates
(c) industrial revolution
(d) none of these

2. The major factors contributing to the decline in death rate in the 20th century were
   (a) improved agricultural practices and increased birth rates
   (b) improved medicine, sanitation, and nutrition
   (c) endemic poverty, low levels of education
   (d) European colonization and improved agricultural practices

3. The world population in 2000 was around
   (a) 8 billion (b) 6.1 billion
   (c) 7.1 billion (d) 5.1 billion

4. In 1960, the world population was around
   (a) 2 billion (b) 3 billion
   (c) 4 billion (d) 4.5 billion

5. Population pyramids are useful to
   (a) express the population growth rates
   (b) express the age-sex distribution of a population
   (c) indicate the birth rates
   (d) indicate the death rates

6. Population ageing is
   (a) the increase in the average age of the population
   (b) the result of decreased death and birth rates
   (c) the trend where more people live to reach old age while fewer children are born
   (d) all of the above

7. The problem with population ageing is
   (a) there may come a time when there are not enough young people to finance or care the old
   (b) population explosion
   (c) increased birth rates
   (d) increased death rates

8. The average life expectancy around the world is currently
   (a) decreasing (b) increasing
   (c) not changing (d) stabilizing

9. Which of the following is a problem not associated with population growth?
(a) Increased resource consumption
(b) Environmental pollution
(c) Food and energy shortages
(d) None of the above

10. The Universal Declaration of Human Rights was proclaimed by the UN in the year
(a) 1946 (b) 1947
(c) 1948 (d) 1949

11. HIV is not likely to be transmitted by which of the following?
(a) Sharing needles or injection equipment
(b) Breast-feeding
(c) Blood transfusion
(d) Mosquito bites

12. The disease which wiped out one-third of the population of Europe in the 12th and 13th centuries was
(a) cholera (b) plague
(c) meningitis (d) diphtheria

13. The major objective of Family Welfare Programmes in India is
(a) disease control
(b) population growth rate control
(c) employment generation
(d) none of the above

14. India Population Project (IPP)-VIII was aimed at
(a) improving health and family welfare services in the urban slums in the cities of Delhi, Calcutta, Hyderabad and Bangalore
(b) improving health and family welfare services in the urban slums in the cities of Delhi, Calcutta, Mumbai and Chennai
(c) a series of birth control programmes in the entire India
(d) improving health and family welfare services in India

15. The objectives of Integrated Child Development Services (ICDS) are
(a) immunization
(b) health check up and referral services
(c) pre-school non-formal education
(d) all of the above

Short-Answer Questions

1. What was the major cause of increased population growth in the 18th century?

2. Define the following terms in connection with population growth.
(a) Birth rate
(b) Growth rate
(c) Doubling time

3. What are the reasons behind the increased population growth in the less developed nations compared with developed nations?

4. What is meant by population pyramid?

5. Explain the consequences of population growth on the following.
(a) Food resources
(b) Water resources
(c) Energy resources

6. Define value education.

7. Differentiate between HIV and AIDS.

8. Why is it not possible to rely on symptoms to know whether someone is infected with HIV?

9. What is the major objective of family welfare programmes in India?

10. Write short notes on the following family welfare programmes in India:
(a) Maternal and Child Health (MCH)
(b) Universal Immunization Programme
(c) Child Survival and Safe Motherhood Project
(d) India Population Project (IPP)
(e) Innovations in Family Planning Services
(f) Child Development

Descriptive Questions

1. Describe the history of population growth on earth mentioning the factors contributing to it.
2. Draw a typical population pyramid of a developing country and discuss how it is likely to differ from that of a developed country.
3. Explain the environmental problems posed by population explosion.
4. Discuss the salient features of the Universal Declaration of Human Rights by UN.
5. Explain the steps that are being taken in India to impart value education from school days.
6. Discuss the process of HIV infection.
7. What are the modes of transmission of HIV and how can it be prevented?
8. What are the steps that have to be taken to control the AIDS epidemic in India?
9. Discuss the role of Information Technology in the protection of environment and human health.

Answers to Objective-Type Questions

1. (c)	2. (b)	3. (b)	4. (b)	5. (b)	6. (d)	7. (a)
8. (b)	9. (d)	10. (c)	11. (d)	12. (b)	13. (b)	14. (a)
15. (d)						

Appendix 1

INTERNATIONAL CONVENTIONS AND PROTOCOLS

In order to deal with regional and global environmental changes, it is necessary to develop new scientific and political mechanisms that could operate at the international level. An international convention is intended to build an international consensus that a particular ecological, wildlife or pollution problem exists. The convention is worded in general terms to allow all countries to "sign on" recognizing that the problem exists and that there is some need for concern and multinational action.

Once a convention has been established, countries can then begin to negotiate specific control actions. The protocol mechanisms allow large problems to be broken down into more achievable steps. The protocol mechanism allows for a wide range of actions to be agreed upon including the control of emissions, the control of production, trade in substances of concern, and financial aid mechanisms. It would not be possible to negotiate all of these items at one time or within one time frame but the protocol process allows for substantial progress to be made in spite of great complexities of the overall actions being taken.

The protocol process can virtually supersede the convention itself. In the case of stratospheric ozone depletion, the Vienna Convention which was the umbrella agreement leading to the Montreal Protocol.

I. MAJOR INTERNATIONAL ENVIRONMENTAL CONVENTIONS

Ramsar Convention (Convention on Wetlands of International Importance especially as Waterfowl Habitat)

Most of the waterfowl that inhabit marshes or swamps are migratory birds. International cooperation to preserve the marshlands has been regarded as necessary in order to protect these migratory birds. In 1971 in Ramsar, Iran, "the International Conference on Preservation of Marshes and Waterfowl" was held, the objectives of which were to recognise the importance of marshes for animals and plants and the ecological system as a whole and to promote the conservation of marshes. In this conference, this convention was produced.

CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora)

There are various kinds of creatures around the world, and they are the members in this ecological system. The rapid decrease of species caused by human activities is emerging as a serious problem in recent years. Plants and animals that have commercial values are in danger of hunting for commercial use. CITES aims to protect wild fauna and flora in danger of extinction by cooperation in restricting international trade between export and import states.

Vienna Convention for the Protection of the Ozone Layer

The ozone layer around the globe absorbs most of the ultra violet rays (UV-B) that harm creatures, but CFCs and some other substances destroy the ozone layer. If the ozone layer is depleted, the amount of UV rays which reaches the ground will increase and in effect human body or ecological balance will be damaged.

People became keenly aware of this mechanism and Vienna Convention for the Protection of the Ozone Layer in 1985, and Montreal Protocol on Substances that Deplete the Ozone Layer in 1987 were adopted.

For the purpose of facilitating developing countries to reduce ODS (Ozone Depleting Substances) smoothly, the Parties to the Montreal Protocol established a fund with contributions by developed countries. The fund provides financial resources to projects to reduce ODS implemented in developing countries.

Basel Convention (Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal)

In the 1980s, some African States suffered from environmental pollution caused by wastes moved from developed European States. To deal with these problems, the Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal, which aims to properly administer the transboundary movements of wastes, was adopted in Basel, Switzerland in March 1989.

Earth Summit—Conventions on Climate Change and Biological Diversity

In 1992, more than 100 heads of state met in Rio de Janeiro, Brazil for the first international Earth Summit convened to address urgent problems of environmental protection and socio-economic development. The assembled leaders signed the Convention on Climate Change and the Convention on Biological Diversity, endorsed the Rio Declaration and the Forest Principles, and adopted **Agenda 21** for achieving sustainable development in the 21st century.

UNFCCC (United Nations Framework Convention on Climate Change)

CO_2 increase in the atmosphere brings about global warming, and it has caused grave concern in recent years. The United Nations Framework Convention on Climate Change (UNFCCC) was adopted in May 1992 in the earth summit in Rio de Janeiro. The objectives of this convention were to stabilize the density of greenhouse gases, and to reduce or limit the emissions of these gases.

CBD (Convention on Biological Diversity)

Convention on Biological Diversity adopted in 1992 in the Earth Summit in Rio de Janeiro, aims for the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of benefits arising out of the utilization of genetic resources.

UNCCD (United Nations Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, particularly in Africa)

The Convention to Combat Desertification provides that developing country Parties affected by desertification undertake to prepare and implement national and regional action programmes as appropriate and that developed country Parties undertake to support such efforts.

Aarhus Convention

The UN/ECE Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters, being adopted on 25th June 1998 in the Danish city of Aarhus, is a new form of environmental agreement. The Aarhus Convention grants the public access to information, public participation in decision-making and access to justice in environmental matters.

International Plant Protection Convention (IPPC)

The International Plant Protection Convention is a treaty deposited with the Director-General of the FAO of the UN. It has basically been designed to control pests, with the more specific purpose of securing common and effective action to prevent the spread and introduction of pests of plants and plant products and promoting measures for their control.

Convention on the Law of the Sea

This convention, establishing the rules governing all uses of the oceans and their resources, lays out a comprehensive regime of law and order in the world's oceans and seas. The United Nations convention entered into force in 1994; however, the US did not access it at that time.

Stockholm Convention on POPs (Persistent Organic Pollutants)

The Stockholm Convention aims to reduce and eliminate 12 POPs that can possibly affect the next generation, such as Dioxin, Furan, and DDT. POPs are chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of living organisms and are toxic to humans and wildlife.

Rotterdam Convention on the Prior Informed Consent (PIC) Procedure for Certain Hazardous Chemicals and Pesticides in International Trade

The Convention establishes a first line of defense by giving importing countries the tools and information they need to identify potential hazards and exclude chemicals they cannot manage safely. If a country agrees to import chemicals, the Convention promotes their safe use through labeling standards, technical assistance, and other forms of support. It also ensures that exporters comply with the requirements. The Rotterdam Convention entered into force on 24th February 2004.

II. MAJOR INTERNATIONAL ENVIRONMENTAL PROTOCOLS

The Montreal Protocol on Substances that Deplete the Ozone Layer

The Vienna Convention for the Protection of the Ozone Layer (1985), which outlines a country's responsibilities for protecting human health and the environment against the adverse effects of ozone depletion, established the framework under which the Montreal Protocol was negotiated.

Cartagena Protocol on Biosafety

Under the Convention on Biodiversity (CBD), this Protocol seeks to protect biological diversity from the potential risks posed by living modified organisms resulting from modern biotechnology. It establishes procedures for ensuring that countries are provided with the information necessary to make informed decisions before agreeing to the import of such organisms into their territory.

Kyoto Protocol

The objective of the Framework Convention was to "*achieve stabilization of the greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.*" The signatories agreed to formulate programmes to mitigate climate change, and the developed country signatories agreed to adopt national policies to reduce anthropogenic emissions of greenhouse gases to their 1990 levels.

The Protocol also provides for three ***Kyoto mechanisms***, to help countries achieve part of these commitments through action to reduce emissions abroad.

1. The Clean Development Mechanism (CDM) is a way to earn credits by investing in emission reduction projects in developing countries.
2. Joint Implementation (JI) is a way to earn credits by investing in emission reduction projects in other developed countries that have taken on a Kyoto target.
3. International Emissions Trading (IET) will permit developed countries that have taken on a Kyoto target to buy and sell credits among themselves.

APPENDIX 2

GLOSSARY

A

Abiotic: A non-living (physical or chemical) component of the environment.

Abatement: The reduction in degree or intensity of pollution.

Acid rain: Precipitation which has a pH of less than 5.6.

Acute toxicity: Any poisonous effect produced within a short period of time, resulting in severe biological harm and often, death.

Adsorption: The adhesion of a substance to the surface of a solid or liquid. Adsorption is often used to extract pollutants, by causing them to be attached to adsorbents such as activated carbon or silica gel. Hydrophobic, or water-repulsing adsorbents, are used to extract oil from waterways in oil spills.

Advanced wastewater treatment: The removal of any dissolved or suspended contaminants beyond secondary treatment. Often, it is the removal of the nutrients—nitrogen and/or phosphorus.

Aeration: The process by which air is circulated through, mixed with or dissolved in a liquid or substance.

Aerobes: Organisms which require molecular oxygen as an electron acceptor for energy production.

Agricultural pollution: The liquid and solid wastes from farming, including runoff from pesticides, fertilizers, and feedlots; erosion and dust from plowing; animal manure and carcasses.

Air pollution: The presence of contaminant substances in the air that do not disperse properly and interfere with human health.

Algae: Simple rootless plants that grow in bodies of water in relative proportion to the amounts of nutrients available. Algal blooms reduce the amount of dissolved oxygen in lakes and rivers and can result in fish kills.

Algae bloom: A phenomenon whereby excessive nutrients within a river, stream or lake cause an explosion of plant life which results in the depletion of the oxygen in the water needed by fish and other aquatic life. Algae bloom is usually the result of urban runoff (of lawn fertilizers, etc.). The potential tragedy is that of a 'fish kill', where the stream life dies in one mass extinction.

Alkalinity: The acid neutralizing capacity of water is known as alkalinity. Most surface waters have alkalinities < 200 mg $CaCO_3$/L, but in limestone areas, the alkalinities can be greater than 1000 mg $CaCO_3$/L. In some cases, pristine surface water has very low alkalinities and therefore they would be adversely impacted by acid mine drainage and acid rain. The alkalinity of precipitation can be from 1 to about 10 mg $CaCO_3$/L. Typically the best alkalinity for aquatic life is between 100 and 120 mg $CaCO_3$/L. Alkalinity is determined using a titrametric or potentiometric method.

Ambient air: Any unconfined portion of the atmosphere; the outside air.

Anaerobes: A group of organisms that do not require molecular oxygen. These organisms obtain their oxygen from inorganic ions such as nitrate or sulfate or from protein.

Anthropogenic: Human-induced or human-caused, derived from the Greek root anthropos meaning 'man'.

Aquatic life: All forms of living things found in water, ranging from bacteria, to fish and rooted plants. Insect larva and zooplankton are also included.

Aqueduct: A pipe or conduit made for bringing water from a source.

Aquifer: An underground bed or layer of earth, gravel or porous stone that contains water, *or* Porous, water-bearing layers of sand, gravel, and rock below the earth's surface; reservoirs for groundwater.

Artificial recharge: The unnatural addition of surface waters to groundwater. Recharge could result from reservoirs, storage basins, leaky canals, direct injection of water into an aquifer, or by spreading water over a large land surface.

Asbestos: A mineral (magnesium silicate) that has been processed and is used to fire proof buildings, insulate electrical wires, and make brake linings in cars. Asbestos can cause cancer if inhaled or ingested.

Attached growth reactor: A reactor in which microorganisms are attached to engineered surfaces within it. Examples of attached growth reactors are the trickling filter and the rotating biological contactor.

Autotrophs: A group of organisms capable of obtaining carbon for synthesis from inorganic carbon sources such as carbon dioxide and its dissolved species (the carbonates). This group includes plants and algae.

B

Background radiation: Radiation from natural radioactive materials in the environment. Includes solar and cosmic radiation and radioactive materials in upper atmosphere, ground, building materials, and human body**.**

Batch system: A system in which there is no transfer of material across its boundary during the time interval of interest.

Benthos: The bottom sediments of rivers, lakes, ponds, etc.

Best management practice: A practice or combination of practices determined to be the most practicable means of preventing or reducing, the amount of pollution generated by nonpoint sources to a level compatible with water quality goals.

Bioassay: Using living organisms to measure the effect of a substance, factor or condition.

Biochemical Oxygen Demand (BOD): The dissolved oxygen required to decompose organic matter in water. It is a measure of pollution since heavy waste loads have a high demand for oxygen.

Biodegradable: Able to be broken down into simpler products by microscopic plants and animals.

Biogeochemical cycle: The cycle of elements through the biotic and abiotic environment.

Biological diversity (Biodiversity): The variety of different species, the genetic variability of each species, and the variety of different ecosystems that they form.

Biomagnification (Biological magnification): A cumulative increase in the concentrations of a persistent substance in successively higher levels of the food chain.

Biomass: (1) The amount of living matter in an area, including plants, large animals and insects; (2) Plant materials and animal waste used as fuel.

Biome: A broad, regional type of ecosystem characterized by distinctive climate and soil conditions and a unique kind of biological community adapted to those conditions.

Biosphere: The global ecosystem; that part of the earth and atmosphere capable of supporting living organisms.

Biota: All the species of plants and animals indigenous to a certain area.

Biotic: Of or relating to life.

Brine: Water that is saturated or partially saturated with salt.

C

Carbon monoxide [CO]: A colourless and odourless gas resulting from incomplete combustion. Gas stoves, fireplaces, kerosene appliances, tobacco smoke, and automobile exhaust are potential sources. Proper ventilation is important to prevent negative health effects such as fatigue, dizziness and nausea.

Carcinogenic: Capable of causing cancer.

Chemical Oxygen Demand (COD): COD is used as a measure of the oxygen equivalent of the organic matter content of the sample. (Only the organic matter that is susceptible to oxidation by strong chemical oxidant). COD is typically used when there are industrial wastewater sources, comparing biological to chemical oxidation in the selection of treatment process and performances. Depending on the waste stream, it can provide insight into the concentration of reduced inorganic metal inorganic, such as ferrous iron, sulfide, and manganese.

Chemotroph: Organisms which obtain energy from the metabolism of chemicals, either organic or inorganic.

Chlorofluorocarbons (CFCs): Stable and artificially-created chemical compounds containing carbon, chlorine, fluorine and sometimes, hydrogen. Chlorofluorocarbons, used primarily to facilitate cooling in refrigerators and air conditioners, have been found to damage the stratospheric ozone layer which protects the earth and its inhabitants from excessive ultraviolet radiation.

Chronic toxicity: The capacity of a substance to cause long-term poisonous health effects in humans, animals, fish, and other organisms.

Closed-loop recycling: Reclaiming or reusing production waste for reuse in an enclosed process.

Closed system: A system in which there is no transfer of material across its boundary during the time interval of interest. (Same as a Batch System.)

Colloids: Small particles which have a negligible settling velocity. These particles have a very small mass, so gravitational force is low compared to surface frictional forces. Typical colloidal sizes range from 10-3 mm to 1 mm.

Combined sewer: A sewer that carries both sanitary sewage and storm water runoff.

Comminution: Mechanical shredding or pulverizing of waste; used in solid and water waste treatment.

Compactor: Equipment that densifies recyclable material and contains it under pressure, not allowing it to expand until it is unloaded.

Composting: The controlled aerobic degradation of organic wastes into a material which can be used as manure.

Conductivity: The theoretical definition of conductivity is the 'reciprocal of the resistance of a cube of a substance 1 cm on a side at a specified temperature'. Typically, the units of measure are microhms/cm (uohms/cm) or microsiemens/cm (uS/cm). Conductivity or specific conductance is a measure of the ability of a fluid to carry a charge which is directly related to the concentration of dissolved substances. As the total dissolved substances in the water increases, the conductivity of the water also increases.

Cone of depression: A depression in groundwater levels around a well in response to groundwater withdrawal or pumping water.

Conservation: Not wasting, and renewing when possible, the natural resources of the world.

Consumers: Organisms which consume protoplasm produced from photosynthesis or consume organisms from higher levels which indirectly consume protoplasm from photosynthesis.

Contaminate: To pollute something, or make it dirty.

D

DDT: An organochloride used as an insecticide. It has been banned since 1969 in most developed countries because it is a probable cause of cancer. However, it is still widely used in developing countries.

Decomposers: Organisms which utilize energy from wastes or dead organisms. Decomposers complete the cycle by returning nutrients to the soil or water and carbon dioxide to the air or water.

Demography: The statistical study of human populations relating to growth rate, age structure, geographic distribution, etc., and their effects on social, economic, and environmental conditions.

Denitrification: The anoxic biological conversion of nitrate to nitrogen gas. It occurs naturally in surface waters low in oxygen, and it can be engineered in wastewater treatment systems.

Deoxygenation: The consumption of oxygen by different aquatic organisms as they oxidize materials in the aquatic environment.

Desalinization: The process of salt removal from sea or brackish water.

Dioxin: A man-made chemical by-product formed during the manufacturing of other chemicals and during incineration. Member of a family of compounds known chemically as dibenzo-p-dioxins. Studies show that dioxin is the most potent animal carcinogen ever tested, as well as the cause of severe weight loss, liver problems, kidney problems, birth defects, and death.

Disinfection: The destruction or inactivation of pathogenic microorganisms.

Dissolved Oxygen (DO): A measure of the amount of oxygen available for biochemical activity in a given amount of water. Low DO levels generally indicate organic pollution.

Dissolved solids: The total amount of dissolved inorganic material present in water or wastes. Excessive dissolved solids make water unsuitable for drinking or industrial uses.

Downcycle: To recover a product at the end of its useful life, break it down into its constituent components, and re-incorporate it into a new product which has an inherent value less than the original product.

Drawdown: The lowering of the water level caused by pumping. It is measured in feet for a given quantity of water pumped during a specified period, or after the pumping level has become constant.

E

Earth charter: A set of principles for sustainable development, environmental protection, and social justice developed by a council appointed by the United Nations.

Earth Day, April 22: Held each year to promote awareness of environmental issues. The first Earth Day was in 1970.

Ecological succession: The sequential replacement of one vegetative community by another through a series of stages; succession ends when the climax community is established.

Ecology: The study of relationships between living things and their surroundings.

Ecosphere: Refers to the entire global ecosystem that comprises atmosphere, lithosphere, hydrosphere, and biosphere as inseparable components.

Ecosystem: A community of living things interacting with one another and with their physical environment, such as a rain forest, pond or estuary.

Effluent: Waste material discharged into the environment which can be treated or untreated.

Electrostatic precipitator: A device which uses an electric field to trap particulate pollutants.

Emission: Waste substances discharged into the air.

Endangered species: A species threatened with extinction.

Endemic: Peculiar to a certain region or country; native to a restricted area; not introduced.

Environment: All of the organic and inorganic components surrounding us, as well as the events, conditions and processes of their interactions.

Environmental ethics: A search for moral values and ethical principles in human relations with the natural world.

Environmental Impact Assessment (EIA): The critical appraisal, both positive and negative, of the likely effects of a proposed project, development, activity or policy on the environment.

Environmentalism: Active participation in attempts to solve environmental pollution and resource problems.

Environmental literacy: Fluency in the principles of ecology that gives us a working knowledge of the basic grammar and underlying syntax of environmental wisdom.

EPA: The U.S. Environmental Protection Agency. Sets environmental protection and enforcement standards. Created in 1970.

Erosion: The wearing away of land surface by wind or water. Erosion occurs naturally from weather or run-off but can be intensified by land-clearing practices.

Estuary: Special environments at the mouth of coastal rivers where fresh water meets sea water. These brackish water ecosystems shelter and feed marine life, birds and wildlife.

Eucaryotic organisms: Organisms which possess a nuclear membrane. This includes all known organisms except viruses and bacteria.

Evapotranspiration: Water loss from soil including evaporation and transpiration from the surfaces of plants.

F

Facultative: A group of microorganisms which prefer or preferentially use molecular oxygen when available, but are capable of using other pathways for energy and synthesis if molecular oxygen is not available.

Fauna: All of the animals present in a given region.

Flora: All of the plants present in a given region.

Food chain: A sequence of organisms, each of which uses the next, lower member of the sequence as a food source.

Food security: The ability of individuals to obtain sufficient food on a day-to-day basis.

Food web: The complex intermeshing of individual food chains in an ecosystem.

Fossil fuels: Fuels such as oil, natural gas, and coal made from decayed plants and animals that lived millions of years ago. These fuels are made of hydrogen and carbon (hydrocarbons).

G

Gaia hypothesis: A theory that the living organisms of the biosphere form a single, complex interacting system that creates and maintains a habitable Earth; named after Gaia, the Greek Earth mother goddess.

Garbage: Another word for solid waste, particularly household waste.

GATT: General Agreement on Tariffs and Trade.

Gene: The functional unit of heredity; the part of the DNA molecule that encodes a single enzyme or structural protein unit. The unit of heredity transmitted from generation to generation during sexual or asexual reproduction. More generally, the term 'gene' may be used in relation to the transmission and inheritance of particular identifiable traits.

Genome: All the genes of a particular organism or species. The complete set of genes and non-coding sequences present in each cell of an organism, or the genes in a complete haploid set of chromosomes of a particular organism.

Global warming: The long-term warming of the planet due to increase in greenhouse gases which trap reflected light, preventing it from exiting to space.

Greenhouse gases: Gases which trap solar radiation. Of the solar energy entering the earth's atmosphere, a portion is reflected back and a portion penetrates onto the earth's surface. The portion reflected back from the earth's surface is at a different wavelength when it entered. Carbon dioxide and other gases, which pass solar radiation, absorb this reflected radiation, increasing the earth's temperature. This is much like a greenhouse, hence the name.

Groundwater: The mass of water in the ground that fills saturated zones of material such as sand, gravel or porous rock.

H

Habitat: The native environment where a plant or animal naturally grows or lives.

Half-life: 1. The time required for a pollutant to lose one-half of its original co-concentration. For example, the biochemical half-life of DDT in the environment is 15 years. 2. The time required for half of the atoms of a radioactive element to undergo self-transmutation or decay (half-life of radium is 1620 years). 3. The time required for the elimination of half a total dose from the body.

Halons: Chemical compounds developed from hydrocarbons by replacing atoms of hydrogen with atoms of halogens, such as fluorine, chlorine, or bromine. CFCs are halons. Halons are widely used as fire extinguishing agents.

Hazardous waste: Waste materials that are inherently dangerous in contact, handling and disposal. They may be toxic, explosive, caustic, or ignitable. Radioactive materials and some biological wastes are also considered hazardous.

Heavy metals: Elements with high molecular weights which are generally toxic in low concentrations to plant and animal life. Examples include mercury, chromium, cadmium, arsenic, and lead.

Heterotrophic: A group of organisms which obtain carbon for synthesis from other organic matter or proteins.

High Density Polyethylene (HDPE): Used to make plastic bottles, milk cartons and other products. It produces toxic fumes when burned. Often referred to as No.2 Plastic.

Humus: The substance which results from decay of plant or animal matter. Biodegradable matters form humus as they decompose.

Hydrocarbons: Compounds found in fossil fuels that contain carbon and hydrogen in various combinations. They are major air pollutants and some may be carcinogenic. Fossil fuels, glues, paints, and solvents contain hydrocarbons. Most people use the terms 'hydrocarbon' and 'volatile organic compounds' (VOCs) to mean the same thing.

Hydrochlorofluorocarbons (HCFCs): Organic substances composed of hydrogen, chlorine, fluorine, and carbon atoms. These chemicals are less stable than CFCs, and are therefore less damaging to the ozone layer.

Hydrofluorocarbons (HFCs): Chemicals with fluorine but no chlorine, and therefore unlikely to damage the ozone layer. However, HFCs are potent greenhouse gases.

Hydrologic cycle: The cyclical movement of water from the ocean to the atmosphere by evaporation through rain to the earth's surface, through runoff and groundwater to streams, and back to the sea.

I

Incineration: The process of burning wastes under controlled conditions.

Inversion: An atmospheric condition occurring when a layer of cool air is trapped by a layer of warm air and is unable to rise. Inversions spread polluted air horizontally rather than vertically so that contaminating substances cannot be dispersed.

K

Kyoto Protocol: An international agreement to reduce greenhouse gas emissions.

L

Landfilling: The placement of wastes into the land under controlled conditions to minimize their migration or effect on the surrounding environment.

Leachate: Liquid that has percolated through solid waste or other matter, extracting dissolved or suspended materials from it.

Leaching: The act of dissolving the soluble portion of a solid mixture by some solvent. An example is the dissolving of inorganic or organic contaminants from refuse in a landfill by infiltrating rain water.

Life-cycle for a product: All stages of a product's development, from extraction of fuel for power to production, marketing, use, and disposal.

Liner: Barrier designed to prevent the leaching of contents from a landfill. Commonly comprised of plastic or dense clay.

LLDPE: Linear low density polyethylene.

M

Mass balance: An organized accounting of all inputs and outputs to an arbitrary but defined system. Stated in other terms, the rate of mass accumulation within a system is equal to the rate of mass input less the rate of mass output plus the rate of mass generation within the system.

Methane [CH_4]: A colourless, odourless, flammable and gaseous hydrocarbon present in natural gas and formed by the decomposition of organic matter, such as in a landfill.

Mixed Liquor Suspended Solids (MLSS): The total suspended solids concentration in the activated sludge tank.

Mixed Liquor Volatile Suspended Solids (MLVSS): The volatile suspended solids concentration in the activated sludge tank.

Mobile source: A moving source of pollution, such as a car or truck.

Municipal Solid Waste (MSW): Residential and commercial trash and/or garbage generated by a particular municipal area.

Mycorrhizae: A symbiotic soil fungi, present in most soils, that attach themselves directly onto the roots of most plants. The fungi help the host plants absorb more water and nutrients while the latter provide them food.

N

NIMBY: The 'not in my backyard' response to building waste management facilities.

Nitrification: The biological oxidation of ammonia and ammonium sequentially to nitrite and then nitrate. It occurs naturally in surface waters, and can be engineered in wastewater treatment systems. The purpose of nitrification in wastewater treatment systems is a reduction in the oxygen demand resulting from the ammonia.

Nitrogen fixation: The conversion of atmospheric (or dissolved) nitrogen gas into nitrate by microorganisms.

Nitrogen oxides: Gases that form when the nitrogen and oxygen in the atmosphere are burned with fossil fuels at high temperatures.

Non-Governmental Organization (NGO): An organization, centered around a cause or causes, that works outside the sphere of governments. NGOs often lobby governments in an attempt to influence policy.

Non-point source: Water contaminant that cannot be traced to a specific point of origin, but rather comes from many different non-specific sources.

Non-renewable resources: Natural resources that are not naturally replenished once they have been harvested. Non-renewable resources can be used up completely or else used up to such a degree that it is economically impractical to obtain any more of them. Fossil fuels and metal ores are examples of non-renewable resources.

Nutrients: Essential elements or compounds in the development of living things. Oxygen, nitrogen and phosphorous are examples. As a pollutant, any element or compound, such as phosphorus or nitrogen, that fuels abnormally high organic growth in aquatic ecosystems (e.g., eutrophication of a lake).

O

Open system: A system in which material is transferred across the system boundary, i.e., enters the system, leaves the system or both.

Organic chemicals: Chemical compounds containing carbon. Historically organic compounds were obtained from vegetable or animal sources. Today, many organic chemicals are synthesized in a laboratory.

Ozone: Pungent and colourless toxic gas that is the major component of smog. It is formed when sunlight triggers chemical reactions involving hydrocarbons and oxides of nitrogen.

Ozone layer: The layer of the upper atmosphere in which a concentration of ozone absorbs a significant amount of potentially hazardous ultraviolet radiation.

P

Particulates: Fine particles such as dust, smoke, fumes, or smog found in emissions and the air.

Parts Per Million (ppm): The number of parts by weight of a substance per million parts of water. This unit is commonly used to represent pollutant concentrations.

PCBs: Polychlorinated biphenyls. A toxic material found in transformers and capacitors. These organic compounds are very persistent in the environment where they accumulate over time.

Pesticides: A substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest. Also, any substance or mixture of substances intended to regulate plant or leaf growth. Pesticides can accumulate in the food chain and/or contaminate the environment, if misused.

PET: Polyethylene terephthalate, the plastic resin in soda bottles and polyester fiberfill.

Photoautotrophic: Organisms which utilize inorganic carbon dioxide for protoplasm synthesis and light for an energy source.

Photochemical smog: Air pollution caused by chemical reactions of various pollutants emitted from different sources.

Phytoplankton: Usually microscopic aquatic plants, sometimes consisting of only one cell.

Plume: In water terms, the extent or boundary of the spread of underground soil or water contamination. In air, a visible emission from a flue or chimney.

Point source pollution: Water pollution sources that may be traced to a specific source, such as a sewer line or a discharge pipe of an industrial facility.

Pollutant: A contaminant that adversely alters the physical, chemical, or biological properties of the environment.

Polycarbonate: Common uses are compact discs and beverage bottles; requires toxic solvents to produce.

Polyethylene Teraphthalate (PET): A type of plastic that is clear or coloured transparent with high gloss. It is used for carbonated beverage bottles and some household cleanser containers. Often referred to as No. 1 Plastic.

Polymer: A natural or synthetic chemical structure where two or more like molecules are joined to form a more complex molecular structure (e.g., polyethylene in plastic).

Polypropilene (PP): Plastic with a smooth surface that cracks easily when bent and is difficult to scratch. Typical uses are battery cases, dairy tubs, jar lids, straws and syrup bottles. It is hard to collect in marketable quantities for recycling and has limited uses in its recycled form. Often referred to as No. 5 Plastic.

Polystyrene (PS): Plastic with a smooth surface that cracks easily when bent. Used for fast food packaging, styrofoam cups and packing peanuts. It takes up a large part of landfill space because of its bulk. Often referred to as No. 6 Plastic.

Polyvinyl Chloride (PVC): A tough and environmentally indestructible plastic that releases hydrochloric acid when burned, *or* Environmentally indestructible plastic that releases toxic hydrocloric acid when burned. It is used for food wraps and containers for personal care products. Often referred to as V-3 or No. 3 Plastic.

Population explosion: Growth of a population at exponential rates to a size that exceeds environmental carrying capacity; usually followed by a population crash.

Potable water: Drinkable water.

Precipitation: Water falling, in a liquid or solid state, from the atmosphere to a land or water surface.

Procaryotic organisms: Organisms which do not have a cellular membrane.

Producers: Autotrophic organisms which produce protoplasm using inorganic carbon and energy from the sun.

R

Radon: Colourless and odourless radioactive gas formed by the decay of radium. When trapped in buildings, concentrations build up, and it can cause health hazards such as lung cancer.

Recycling: To recover a product at the end of its useful life, break it down into its constituent components, and re-incorporate it into a new product which has an inherent value equal to the original product.

Refuse: A general term for solid waste materials, also called garbage or trash.

Respiratory system: A body's system for breathing, including the nose, throat, and lungs.

Resource recovery: The process of obtaining materials or energy, particularly from solid waste.

Risk assessment: The qualitative and quantitative evaluation performed in an effort to define the risk posed to human health and/or the environment by the presence or potential presence and/or use of specific pollutants.

River basin: The land area drained by a river and its tributaries.

Rubbish: Solid waste that does not contain food waste.

Runoff: Water from precipitation or irrigation that flows over the ground surface and returns to streams. It can collect pollutants from the air or land and carry them to the receiving waters.

S

Secured landfill: A landfill which has containment measures such as liners and a leachate collection system, so that materials placed in the landfill will not migrate into the surrounding soil, air and water.

Sedimentation: The gravity settling, and thus removal of materials more dense than the suspending fluid.

Sewage: The waste and wastewater produced by residential and commercial establishments and discharged into sewers.

Sludge: A product of the treatment process as particles in waste are converted to solids.

Smog (photochemical smog): Literally, a contraction of 'smoke' and 'fog'; the colloquial term used for photochemical fog, which includes ozone and numerous other contaminants. Smog usually adds a brownish haze to the atmosphere.

Solid waste: Useless, unwanted or discarded material with insufficient liquid content to be free flowing. It may be agricultural, commercial, industrial, institutional, municipal, or residential in nature.

Source reduction: The elimination or reduction of the waste at the source by modification of the actual process which produces the waste.

Source separation: The sorting of specific waste materials prior to their collection or deposition into a collection container.

Species: A group of organisms capable of interbreeding with each other but not with members of other species. (This is a simplified definition; species concept is much more complex.) A taxonomic rank below a genus, consisting of similar individuals capable of exchanging genes or interbreeding.

Stationary source: A non-moving source of pollution, such as a factory smokestack.

Stewardship: Taking responsibility and caring for the earth or any part of it. Includes responsibility in using resources and creating as little waste and pollution as possible.

Sterilization: The destruction or inactivation of all microorganisms.

Stratosphere: The layer of air that extends from about 10 to 30 mile above the surface of the earth.

Subsurface water: All water which occurs below the ground surface.

Sulfur dioxide: A colourless gas that can bother the lungs. It is formed when fossil fuels that contain sulfur are burned. It is also given off when volcanoes erupt.

Surface water: Water on the earth's surface exposed to the atmosphere, e.g., rivers, lakes, streams, oceans, ponds, reservoirs, etc.

Suspended growth reactor: A reactor in which the microorganisms are suspended in the wastewater. Examples of suspended growth reactors are activated sludge reactors and anaerobic digesters.

Sustainable development: A principle which states that a development plan must not compromise the welfare of future generations for the benefit of present generations.

T

Taxon (taxa): Any named group of organisms.

Thermal pollution: The impairment of water quality through temperature increase; usually occurs as a result of industrial cooling water discharges.

Total dissolved solids: The total amount of solid material dissolved in one liter of water.

Toxic: Describes something that can be poisonous or deadly if it is eaten, touched, or inhaled in large enough amounts.

Toxicity: The quality or degree of being poisonous or harmful to plant or animal life.

Trace contaminants: Contamination found in trace (very low) levels.

Transpiration: The loss of water from plants through leaves and other parts. This loss can be a significant amount of water during very dry periods.

Trash: Material considered worthless, unnecessary or offensive that is usually thrown away.

Trickling filter: An attached growth biological process in which the microbial film is attached to non-moving rock or plastic media.

Trommel: A rotary cylindrical screen that is typically inclined at a downward angle when, combined with the tumbling action of the trommel, separates materials of different density.

Trommel screens are used to separate commingled recyclables, municipal solid waste components, or to screen finished compost from windrow and aerated static pile systems.

Trophic level: A level in the food chain. The first trophic level consists of the primary producers—autotrophs. The second trophic level is vegetarians which consume autotrophic organisms.

Troposphere: The lower atmosphere, from the earth's surface to approximately 12 km. This portion of the earth's atmosphere contains about 95 per cent of the atmospheric gases. The temperature gradually declines through this region.

Turbidity: The property of water which prevents the passage of light through it, usually caused by the presence or suspended and colloidal impurities in water.

U

Ultraviolet Radiation (UV): Electromagnetic radiation in the wavelength range of 200 to 400 nanometres.

Upcycling: Turning waste into more valuable products.

V

Vermicomposting: Use of red worms to compost organic waste.

Volatile Organic Compounds (VOCs): VOCs are made as secondary petrochemicals. They include light alcohols, acetone, trichloroethylene, percholoroethylene, dichloroethylene, benzene, vinyl chloride, toluene, and methylene chloride. These potentially toxic chemicals are used as solvents, degreasers, paints, thinners, and fuels. Because of their volatile nature, they readily evaporate into the air, increasing the potential exposure to humans. Due to their low water solubility, environmental persistence, and widespread industrial use, they are commonly found in soil and ground water.

Volume reduction: Processing waste materials to decrease the amount of space they occupy. It is accomplished by mechanical, thermal or biological means.

W

Waste exchange: A system in which one person's waste becomes another's resource.

Waste stream: The flow of waste material from generation to disposal.

Water table: The top layer of the zone of saturation; undulates according to the surface topography and subsurface structure.

Wetland: Semi-aquatic land, land that is either inundated or saturated by water for varying periods of time during each year, and supports aquatic vegetation which is specifically adapted for saturated soil conditions.

Y

Yard waste: Leaves, grass clippings and other organic wastes produced as part of yard and garden development and maintenance.

Z

Zooplankton: Tiny aquatic animals eaten by fish.

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