MANGALAYATAN
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ENVIRONMENTAL SCIENCE

ABO-1200

Self Learning Material

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Directorate of Distance & Online Education

MANGALAYATAN UNIVERSITY
ALIGARH–202146
UTTAR PRADESH

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PREFACE

In this course, we shall deal with various aspects of **Environmental Communication.**

- CONCEPT OF ENVIRONMENT
- ECOLOGY AND ECOSYSTEMS
- ENVIRONMENTAL POLLUTION OF GLOBAL ENVIRONMENTAL ISSUES
- NATURAL RESOURCE MANAGEMENT AND BIODIVERSITY CONSERVATION
- ENVIRONMENTAL EDUCATION AND MANAGEMENT

ENVIRONMENTAL COMMUNICATION

Objectives :

1. *Understanding of major concepts in environmental sciences and creating the awareness about environmental problems among people;*
2. *Recognize the interconnectedness of multiple factors in environmental challenges.*
3. *Imparting basic knowledge about the environment and its allied problems to develop an attitude of concern for the environment in respect to environment protection and environment improvement.*
4. *Motivating students to participate in Develop analytical skills, critical thinking, in identifying and solving environmental problems.*

Course Content

UNIT-I : CONCEPT OF ENVIRONMENT

Definition and concept of environment, Types and components of environment (Lithosphere, Atmosphere, hydrosphere, Biosphere); Scope and multidisciplinary nature of the subject; man environment relationships.

UNIT–2 : ECOLOGY AND ECOSYSTEM

Concepts of Ecology : Subdivisions of ecology; Ecological factors-climatie, edaphic, physiographic and biotic, Concept of Biological clock, physiological adaptation of hydrophytes, Xerophytes, mesophytes, Ecological Succession and classification (hydrosere, xerosere, mesosere etc).

Structure and Functions of Ecosystem; (a) forest ecosystem (b) Grassland ecosystem (c) Desert ecosystem (d) Aquatic ecosystem (ponds, streams, lakes, rivers, oceans, estuaries); Trophic levels, Ecological Pyramids; food chains and food webs; Energy flow in an ecosystem; Ecological Interactions; Ecotone; habitat; Ecological Niehe; Resilience.

UNIT-3 : ENVIRONMENTAL POLLUTION AND GLOBAL ENVIRONMENTAL ISSUES

Environmental pollution; types, causes, effects and controls; Air, water, soil, noise, thermal and radioactive pollution; Solid waste management; Control measures of urban and industrial waste, special reference *e*-waste, biomedical waste; Climate change; global warming; ozone layer depletion; acid rain and its impacts on human communities and agriculture; Case studies on pollution Tragedies; Love canal, Bhopal Gas, Endosulfan and Minamata; International Agreements : IPCC, Montreal and Kyoto protocol.

UNIT-4 : NATURAL RESOURCE MANAGEMENT AND BIODIVIERSITY CONSERVATION

Renewable and non-renewable energy resources, use of alternate energy resources. Water resource; sources, usage, over-exploitation and sustainable management of water resources; resources; Conflicts

over water (international and inter-state); Land resources; land use change, land degradation, soil erosion and decertification; Forest Resources; types of forest in India; importance of forests, deforestation, Disaster management; floods, earthquake, cyclones and landslides.

Conservation of biodiversity : *In-situ and Ex-situ* conservation of biodiversity; IUCN-Red Data Book categories; Hot spots in India; Biomes; Role of Govt. and Non-Government organizations in Conservation of Biodiversity in India ; International biodiversity conservation practices and strategies.

UNIT-5: ENVIRONMENTAL EDUCATION AND MANAGEMENT

Environmental Education and Movements : Goals of environmental education; Environmental education at primary, secondary and tetriary level Chipko, Silent Valley, Bishnoi, Narmada bacchao Andolan, and Tehri Dam Confliet; Environmental communication and public awareness; Environmental ethics; Green Politics, Earth Hour, Green Option Technologies; EIA-Principles and Process : ISO standards : ISO 9000 and 14000; Environment Laws and Practices.

CONTENTS

UNIT

1

CONCEPT OF ENVIRONMENT

STRUCTURE

• DEFINITION OF ENVIRONMENT

The term environment is derived from the French word **Environed**, which means surroundings. It is considered as a composite term for the conditions in which organisms live. **Environment (Protection) Act, 1986 defined environment as the sum total of water, air and land, their inter-relationships among themselves and with the human beings, other living beings and property.** Environment thus refers to the totality of all conditions and influences that affect the development and life of living organisms. Environmentalists defined environment as the mother of natural resources–energy, land, water, atmosphere and minerals. The flora, fauna and micro-organisms as well as man made structures in our surroundings have a bi-directional interaction with us directly or indirectly.

Urban environment is somewhat different from rural environment. Most of the natural landscapes in cities have been modified by man made artificial structures like multi-storeyed buildings, commercial complexes, factories, transportation network and so on. Urban air, water and soil are loaded with various types of pollutants and wastes. Diversity of plants and animals in urban area is much less as compared to rural environment.

• MULTIDISCIPLINARY NATURE OF ENVIRONMENTAL STUDIES

Environmental science involves the study of chemical species existing in various segments of the environment, their sources, pathways, reactions and their consequences on the activities of human beings and living organisms. It is a multidisciplinary subject where we deal with various disciplines of science, social science, law and engineering etc. in a holistic manner.

- Life sciences including zoology, botany, microbiology, genetics and biochemistry help in understanding the biotic components and their interactions. Genetics and biotechnology are emerging as useful tools for tackling environmental problems.
- For understanding the physical and chemical structure of abiotic components of environment along with mass and energy transfers we have to make use of basic concept of chemistry, physics, geology, meteorology,

oceanography,and geography. Computer science, mathematics and statistics likewise serve as effective tools in environmental modelling.

- Nano technology, chemical engineering, hydraulics, civil engineering etc. provide the technical solutions to environmental pollution control and waste treatment that are extremely important to protect the fragile environment.
- Subjects like economics, sociology and management provide the inputs for dealing with the socio-economic aspects associated with various development activities.
- Environmental laws provide the guidelines and legal measures for effective management and protection of environment.
- Environmental education and mass communication are instrumental in disseminating environmental awareness.

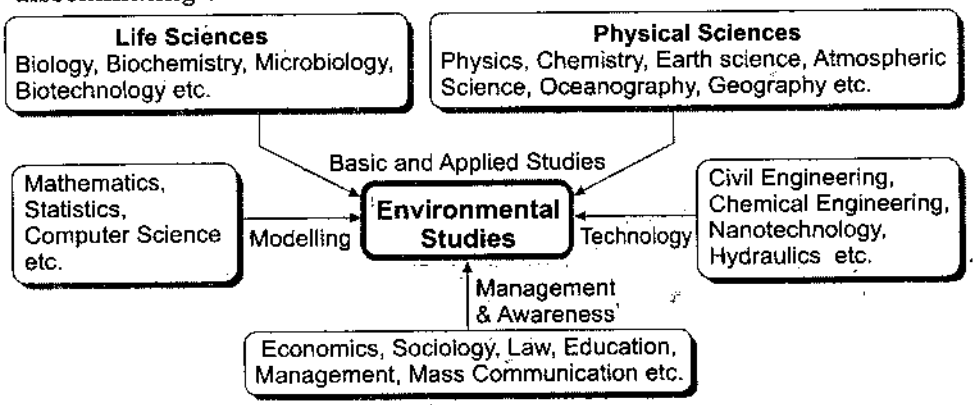


Fig. 1. Multidisciplinary nature of environmental studies.

• SCOPE OF ENVIRONMENTAL STUDIES

The scope of Environmental Studies has expanded dramatically recently. It encompasses a large number of areas and aspects which may be listed below.

- Natural resources, their conservation and management.
- Environmental pollution and control.
- Ecology and biodiversity.
- Social issues in relation to development and environment.
- Natural disaster.
- Human population and environment.

Environmental studies can also be highly specialized concentrating on more technical aspects like environmental science and environmental engineering. Now several career options have emerged in this field that are broadly categorized as follows.

1. Need for Trained Persons. There is a need for trained manpower at every level to deal with environmental issues like clean drinking water, fresh air, fertile land, nutritious food and hygienic living conditions.

2. Demand for Environmental Experts. Environmental experts are now in great demand in industries for adopting green cleaner technologies and to cut down the costs of effluent treatment.

3. Skilled environment scientists have an important role in examining various environmental problems in a scientific manner. They can carry out research and development activities for pollution prevention and sustainable development.

4. Environmental management, environmental biotechnology and business administration are providing new carrier opportunities.

5. Green Advocacy. Since the pollution control laws are becoming more stringent, the need for lawyers has emerged, who should be able to plead the cases related to pollution problems.

6. Green Marketing. While ensuring the quality products with ISO mark, there is an increasing emphasis on marketing goods that are ecofriendly. So environmental auditors and managers would be in great demand in the coming years.

7. Green Media. Environmental awareness among public can be spread through mass media like newspaper, television, radio, magazines etc. for which environmentally educated persons are required.

8. Environmental Consultancy. Many non-governmental organizations (NGO's), industries, policy making committees and government bodies are engaging environmental consultants for systematically studying and tackling environment related problems.

• IMPORTANCE OF ENVIRONMENT

Environment belongs to all of us and we have a responsibility to contribute towards its conservation and protection. Environmental changes and our ability to cope with it, is interwoven with a complex web of implications. That is why we find an internationally observed environmental calender to mark some important aspects of environment.

Environmental Calender.	
World Wetland Day	February 2
World Forest Day	March 21
World Day for Water	March 22
World Meteorological Day	March 23
Earth Day	April 22
International Biodiversity Day	May 22
Anti-tobacco Day	May 31
World Environment Day	June 5
World Ocean Day	June 8
World Population Day	July 11
Ozone Week	September 16–23
Green Consumer Day	September 28
World Farm Animal's Day	October 2
World Animal Welfare Day	October 4
Wildlife Week	October 1–7
International Day for Natural Disaster Reduction	October 13
World Conservation Day	October 24
International Day for Biological Diversity	December 29

Global Nature of Environment.

Issues like global warming, depletion of ozone layer, acid rains, loss of global biodiversity, dwindling of forests and energy resources which affect the mankind as a whole are global in nature and for that we have to think and plan globally.

Local Nature of Environment.

For dealing with local environmental issues like soil erosion, water logging, impact of mining and hydroelectric project, disposal of solid waste, river or lake water pollution, arsenic pollution of ground water, fluorosis in local population etc., we have to think and act locally. In order to make people conscious about those aspects of environment with which they are so intimately associated, it is necessary to make everyone environmentally educated.

Individuallstic Nature of Environment.

Environmental issues deal with the most mundane problems of life like dealing with clean drinking water, fresh air, fertile land, hygienic living conditions, nutritious food and sustainable development. If we want to live in a safe, secure, aesthetically beautiful and healthy environment for a long time, it is most essential to realise the value of environment.

• IMPORTANCE OF ENVIRONMENTAL STUDIES

Environmental studies are extremely important to handle current environmental issues properly.

1. To Protect the Fragile Environment.

Environmental concern was only after the **Stockholm Conference** of 1972 that different countries started giving serious thoughts to environmental problems. As a sequel to the Stockholm meet, Rio Earth Summit of 1992 and Johannesburg Earth Summit of 2002, action plans were initiated by many governments. The voluntary agencies took up the cudgels against environment degrading projects and industries. Environmental studies can be instrumental to attain sustainability and to protect the fragile environment from eco-catastrophe. Environmental protection can however be achieved through a well orchestrated international plan of action, direct investments, organising research in the institutions, educating the people and developing ecofriendly technologies.

2. Environmental Studies Provide the Knowledge About :

- *Maintenance of environmental quality.*
- *Balancing the ecosystem.*
- *To restrict and regulate the exploitation of natural resources.*
- *To renovate, recycle and reuse the waste materials.*
- *To adopt engineered technology without creating adverse effects on the environment.*
- *To control over population and over consumption of resources.*
- *To promote environmental education and training among people.*
- *To formulate laws and regulations to control pollution.*

• NEED FOR PUBLIC AWARENESS

International Efforts for Environment.

The United Nations Conference on Environment and Development held at Rio de Janeiro in 1992 and popularly known as **Earth Summit** followed by **World Summit** on Sustainable Development at Johannesburg in 2002, have highlighted the key issues of global environmental concern. They have also attracted the attention of the general public towards the deteriorating environment. Award of **Noble Peace Prize** (2004) to an environmentalist, Wangari Maathai came as a landmark decision showing increasing global concern towards environmental issues and recognition to efforts being made for environmental conservation and protection.

Public Awareness for Environment.

Any government at its own level can not achieve the goal of sustainable development until the public is made aware about the environmental and ecological crisis. The public must know about the fact that if we are degrading our environment we are actually imbalancing our ecosystem. This is because we are a part of complex network of environment where every component is interlinked.

Methods to Propagate Public Awareness.

1. **Among students through education.** Environmental education must be imparted to the students right from the childhood stage. It is a welcome step that now we are introducing environmental studies as a subject at all stages, following the directives of the Supreme Court.

2. **Among people through mass-media.** Media can play the key role to make the public aware about environmental issues through articles, plantation campaigns, real eco-disaster stories and success stories of conservation efforts.

3. **Among planners, decision makers, politicians and administrators.** Since this elite section of the society plays the most important role in shaping the future of the country, so it is most urgent to give them necessary orientation and training through specially organised workshops and seminars. Publication of environment related resource material by **Ministry of Environment and Forests** can help keeping this section abreast of the latest developments in the field. Public awareness is thus extremely essential to conserve the fast depleting natural resources, protection of fragile ecosystem, control of over population, food security and to attain sustainability.

Role of Non-Government Organizations (NGO's).

NGO's can be very effective in organizing public movements for the protection of environment through creation of awareness. They can act both as an **action group** or a **pressure group**. The **Chipko Movement** or **Narmada Bachao Andolan** are some of the instances where NGO's have played a landmark role for conservation of environment. The World Wide Fund (WWF) for Nature, India, Centre for Science and Environment (CSE), Kerala, Sastra Sahitya Parishad and many others are playing a significant role in creating environmental awareness through research and extension work. People should be environmentally educated and conscious for environmental protection. It is aptly said—**If you want to act green, first think green.**

Contemporary Indian Environmentalists.

In India, efforts to raise environmental awareness have been initiated and several landmark judgements related to environmental litigations have highlighted the importance of this subject to general public. Two noted personalities who must be mentioned here are Justice Kuldeep Singh, the **green judge** and Mr. M.C. Mehta, the **green advocate** have immensely contributed to the awareness of environment.

In 1991, the Supreme Court issued directives to make all curricula environment oriented. This directive was, in fact, in response to a Public Interest Litigation (PIL) filed by M.C. Mehta vs. Union of India (1988) that prompted the apex court to give a mandate for creating environmental awareness among people. Based on the judgement, environmental studies is being taught as a compulsory subject to all students.

Environmentalists like Shri Sunder Lal Bahuguna, known for his **Chipko movement** and **Tehri Bachao Andolan**, Smt. Medha Patekar and Ms. Arundhati Roy known for their **Narmada Bachao Andolan**, the Magsaysay awardee Shri Rajender Singh known for his water conservation efforts are some contemporary activists.

Our late Prime Minister Mrs. Indira Gandhi was instrumental in introducing the concept of environmental protection in the constitution as a fundamental duty while Mrs. Maenka Gandhi, former environment minister, has worked a lot for the protection of wildlife. Shri Anil Agarwal, the founder chairman of Centre for Science and Environment has first published the citizens report on environment. Even with such key persons, India is yet to achieve a lot for environmental protection and its awareness.

Concept of Ecomark. In order to increase consumer awareness about environment, the Ministry of Environment and Forests has introduced a scheme of eco-labelling of environment friendly products with **Eco-mark** in February 20, 1991. **Eco-clubs** for children and **Eco-task force** for army men have also been launched by the government in a drive to disseminate environmental awareness.

Today every body talks of environment, but only a few know what needs to be done. Unfortunately, environmental awareness campaigns have very often been exploited for political propaganda rather than being an integral part of our educational programmes. Environment is not taken as our **real-life** situation even knowing that human sustenance and security are at stake.

In a nutshell, it is absolutely essential to create environmental awareness among public, because :

- Environment belongs to all and public participation is must for successful implementation of environment friendly plans.
- It is necessary to change the self-oriented attitude to earth-oriented approach in a technologically advanced society.
- People must know the serious health impacts of environmental pollution and their right to live in a healthy environment.
- There is an urgent need to make people aware about sustainability principles. Henry D. Thoreau had rightly said, **What is the use of a beautiful house if you do not have a decent planet to put it on?** Even if we begin today, the restoration is expected in the next 50 years.

• QUESTIONS

1. Explain multidisciplinary nature of environmental sciences.
2. What is the scope of environmental studies?
3. How would environmental awareness help to protect our environment?
4. What is green marketing?

SHORT ANSWER QUESTIONS

1. *List major areas of environmental concern.*

   Ans. (i) Agricultural productivity (ii) Land use pattern (iii) Water resources (iv) Irrigation techniques (v) Industrialization and urbanization (vi) Enormous waste production and pollution (vii) Health (viii) High incidence of disease and malnutrition. Other areas of concern include : Forests, wildlife, population crash, environmental laws and environmental protection.

2. *Why environmental awareness is needed?*

Ans. Because awareness makes the individual conscious about physical, social and aesthetic aspects of environment, *i.e.*, air, water, land, flora, fauna and natural resources.

3. *List reasons responsible for wide spread environmental ignorance.*

Ans. (i) Our educational courses in science, technology, economics etc. have so far failed to integrate the knowledge in environmental aspects as an essential component of the curriculum.

(ii) Our planners, decision makers, administrators and politicians have not been trained so as to consider the environmental aspects associated with their plans.

(iii) Quite often, there is purposeful concealment of information about environmental aspects in some ambitious development project.

(iv) There is greater consideration of economic gains that overshadows the basic environmental issues.

4. *How many components are required to build up the environmental awareness?*

Ans. Four components are required, that is, awareness, exposure to real life situations, conservation and sustainable development.

MULTIPLE CHOICE QUESTIONS

1. Environment means
   (a) Sum total of all conditions that affect life of living organisms
   (b) A beautiful landscape
   (c) Forest cover
   (d) Industrial production
2. The Earth Summit was held at
   (a) Geneva (b) Rio de Janeiro
   (c) USA (d) CIS
3. Increasing industrialization is affecting man by
   (a) Polluting the environment (b) Providing more jobs
   (c) Producing more goods (d) Utilizing waste land
4. Environment friendly products are given
   (a) Ecomark (b) ISO 14000 certification
   (c) Both (a) and (b) (d) Green mark
5. Ecomark of India is
   (a) An earthen pitcher (b) Green tree
   (c) Umbrella (d) Flag

FILL IN THE BLANKS

1. The World Summit on sustainable development was held at ..... in ..... .
2. World Environmental Day is celebrated on ..... .
3. The world's first Inter-governmental Conference on Environmental Education in 1977 was held in ..... .
4. ..... was awarded the Noble Peace Prize in 2004 for her contribution towards environmental conservation.
5. Mr. ..... filed Public Interest Litigation for creating environmental awareness among public.
6. When we plant new trees, we plant the ..... .

ANSWERS

Multiple Choice Questions.

1. (a) 2. (b) 3. (a) 4. (c) 5. (a)

Fill in the Blanks.

1. Johannesburg, 2002
2. June, 5th
3. Tbilisi, Georgia
4. Wangari Maathai
5. M.C. Mehta
6. Seeds of peace

UNIT

2

ECOLOGY AND ECOSYSTEM

STRUCTURE

- Concept of an Ecosystem
- Types and Components of Ecosystem
- Structure and Functions of an Ecosystem
- Trophic Structure, Food Chains, Food Web and Ecological Pyramids
- Energy Flow in an Ecosystem and Productivity
- Ecological Succession, Xerarch and Hydrarch
- Grassland Ecosystem, Forest Ecosystem and Desert Ecosystem
- Aquatic Ecosystems
- Questions and Short Answer Questions
- Multiple Choice Questions, Fill in the Blanks and True or False

• CONCEPT OF AN ECOSYSTEM

The term **Ecology** (Greek Oikos-house, logos-study) was coined by German biologist **Ernst Haeckel** in 1869. Ecology deals with the study of interactions between living organisms and their physical environment. Now ecology is defined as the study of ecosystems. The term ecosystem was proposed by **A.G. Tansley** in 1935 where **eco** implies the environment and **system** denotes an interacting, interdependent, integrated complex. **Ecosystem** may be defined as the system resulting from the integration of all living and non-living factors of the environment. Thus any structural and functional unit of biosphere where the organisms interact with the physical environment so that a flow of energy leads to clearly defined trophic structure, biotic diversity and material cycle (*i.e.*, exchange of materials between living and non-living components) within the system is known as an **ecological system or ecosystem**.

Earth is a giant ecosystem where abiotic and biotic components are constantly acting and reacting with each other bringing structural and functional changes in it. This vast ecosystem-biosphere is subdivided into units of smaller ecosystems such as terrestrial and aquatic ecosystems. These systems may be freely exchanging energy and matter from outside—an **open ecosystem** or may be isolated from outside—a **closed ecosystem.**

An ecosystem is normally an open system with a continuous but variable, influx and loss of material and energy. It is a basic, functional unit with no limits of boundaries. Thus an ecosystem represents the **highest level of ecological integration** which is energy based and this functional unit is capable of energy transformation, accumulation and circulation. Its main function in ecological sense is to emphasize obligatory relationships, interdependence and casual relations.

• TYPES OF ECOSYSTEMS

1. Natural Ecosystems (Self operating). These systems operate by themselves under natural conditions without any major interference by man.These are further divided into following ecosystems :

(i) Terrestrial ecosystem includes forest, grassland and desert etc.

(ii) Aquatic ecosystem may be further distinguished as

(a) Fresh water which may be lotic (running water as spring, stream or rivers) or lentic (standing water as lake, pond, pools, ditch, puddles, swamp etc.).

(b) Marine water such as ocean (deep bodies) or sea or estuary (shallow ones).

2. Artificial (Man-engineered) Ecosystems. These are maintained artificially by man where, by addition of energy and planned manipulations, natural balance is disturbed regularly. Crop, urban, industrial, space and control of biotic community as well as the physico-chemical environment are man-engineered ecosystems.

3. Space Ecosystem is also recognised.

The common features of all ecosystems-terrestrial, aquatic and agricultural are the interactions of the autotrophic and heterotrophic components.

• COMPONENTS OF ECOSYSTEM

An ecosystem has two major components—biotic and abiotic.

(A) Biotic (Living) Components.

Plants, animals and micro-organisms having different nutritional behaviour constitute the biotic component of an ecosystem.

1. Producers (or Autotrophs-Self nourishing). Producers are mainly chlorophyll bearing green plants (**photo autotrophs**) which can synthesize their food in presence of sunlight making use of CO_2 and water through the process of photosynthesis. Since plants convert solar energy into chemical energy so they must be better called converters or transducers. Chemosynthetic organisms or **chemo-autotrophs** can also synthesize some organic matter by the oxidation of certain chemicals in absence of sunlight.

2. Consumers (or Heterotrophs or Phagotrophs). Consumers consume the matter built up by the producers. They utilise, rearrange and decompose complex materials.

[**Note.** The major autotrophic metabolism occurs in the upper **green belt** stratum where solar energy is available while the intense heterotrophic metabolism occurs in the lower **brown belt** where organic matter accumulates in soil and sediments.]

Consumers are of following types.

(i) Herbivores. They feed directly on producers and hence are known as primary consumers, *e.g.*, rabbit, deer, cattles, insects etc. Elton (1927) called herbivores as **key industry animals** because they convert plants into animal materials.

(ii) Carnivores (Meat eaters). They feed on other consumers. If they feed on herbivores, they are called secondary consumers (*e.g.*, frog, birds, cat) and if they prey on other carnivores (snake, peacock), they are known as tertiary carnivores/consumers. Lion, tiger etc. which cannot be preyed are called **top carnivores** since they occupy top position in the food chain.

(iii) Omnivores. They feed on both plants and animals, *e.g.*, rat, fox, birds and man.

(iv) Detritivores (Detritus feeders or saprotrophs). They feed on partially decomposed matter such as termites, ants, crabs, earthworms etc.

3. Decomposers (or Micro-consumers). Decomposers are saprophytic (osmotrophs) micro-organisms such as bacteria, actinomycetes and fungi. They derive their nutrition by breaking down complex organic compounds and release inorganic nutrients in environment, making them available again to producers.

The biotic component of any ecosystem may be thought of as the **functional kingdom of nature**, since they are based on the type of nutrition and the energy source used. The entire earth is considered as an ecosystem which is referred to as **biosphere or ecosphere.**

(B) Abiotic (Non-living) Components.

Structurally abiotic components include

1. Climatic regime. Precipitation, temperature, sunlight, intensity of solar flux, wind etc. have a strong influence on the ecosystem.

2. Inorganic substances. These are C, N, H, O, P, S involved in material cycles. The amount of these substances present in an ecosystem is known as **standing state or standing quality.**

3. Organic Substances. Carbohydrates, proteins, lipids and humic substances link the abiotic components with the biotic components. All the biotic and abiotic components of an ecosystem are influenced by each other and are linked together through energy flow and matter cycling.

• STRUCTURE OF AN ECOSYSTEM

The structure of an ecosystem is characterised by the composition and organisation of biotic communities and abiotic components. The major structural features of an ecosystem are :

1. Species Composition. Every ecosystem has its own type of species composition which differs from other ecosystems.

2. Stratification. The organisms in each ecosystem form one or more layers or strata each comprising the population of particular kind of species. In some ecosystems like tropical rain forests, the crown of trees, bushes and ground vegetation form different strata and are occupied by different species. On the other hand, desert ecosystem shows a low discontinuous herb layer consisting of extensive bare patches of soil.

3. The **quantity and distribution** of non-living materials such as nutrients and water etc.

4. The range or gradient of conditions of existence such as temperature and light etc.

• FUNCTIONS OF AN ECOSYSTEM

Every ecosystem performs under natural conditions in a delicately balanced and systematic controlled manner. Functionally, the biotic and abiotic components of ecosystem are so interwoven into the fabric of nature that their separation from each other is practically very difficult. The producers, green plants, fix **radiant energy** and with the help of minerals (C, H, O, N, P, K, Ca, Mg, Zn, Fe etc.) taken from the soil and aerial environment **(nutrient pool)** they build up complex organic matter (carbohydrates, fats, proteins, nucleic acids etc.). Herbivores feed on plants and in turn serve as food for carnivores. Decomposers breakdown complex organic materials into simple inorganic products which can be used by the producers.

The two ecological processes of **energy flow and nutrient cycling**, involving interaction between the physico-chemical environment and the biotic communities constitute the **heart of the ecosystem dynamics** (Fig. 1). The major functional features of an ecosystem are as follows :

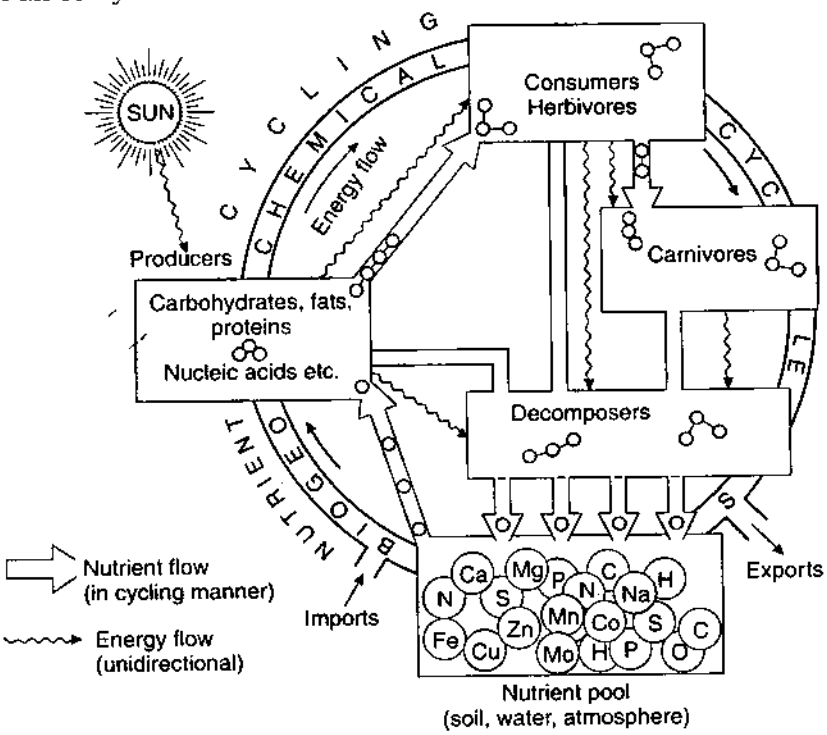


Fig. 1. Model of an ecosystem to show it's structure and function. Nutrient cycling and energy flow are mediated through food chain.

TROPHIC STRUCTURE.

The trophic structure of an ecosystem is a kind of producer-consumer arrangement and their interaction with population size. Each food level is known as **trophic level** and the amount of living matter at each trophic level at a given time is known as **standing crop or standing biomass.** In the ecosystem various trophic levels are connected through food chain.

(i) Food Chains.

The transfer of food energy from the producers, through a series of organisms (herbivores to carnivores to decomposers) with repeated eating and being eaten, is known as **food chain.** All organisms, living or dead, are potential food for some other organisms, hence there is no waste in the functioning of a natural ecosystem. Some examples of simple food chain are :

Grass → Grass hopper → Frog → Snake → Hawk

(Grassland ecosystem)

Phytoplanktons → Water fleas → Small fish → Large fish → Tuna

(Pond ecosystem)

Types of Food Chains.

(a) Grazing food chain. It starts from green plants (primary producers), goes to grazing herbivores and culminates to carnivores (Fig. 2). The chain thus depends on **autotrophic energy capture** and movement of this captured energy to carnivores. Examples constitute sequence of

Phytoplanktons → Zooplanktons → Fish

Grass → Rabbit → Fox

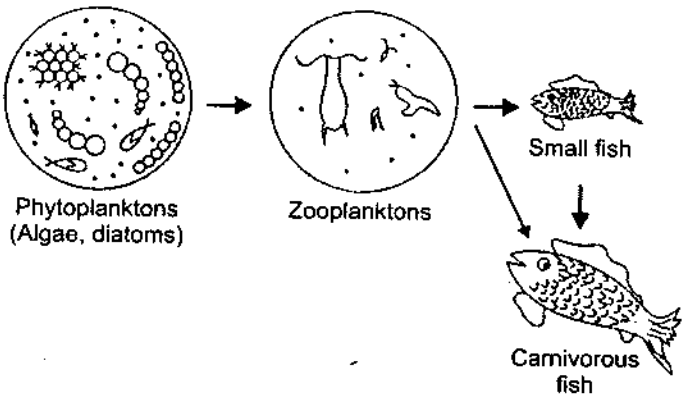


Fig. 2. A grazing food chain in a pond ecosystem.

(b) Detritus food chain. It starts from dead organic matter and passes through micro-organisms to detritivores (organisms feeding on detritus), their predators and decomposers. The ecosystems exhibiting detritus food chain are less dependent on direct solar energy. These depend chiefly on the influx of organic matter produced in another ecosystem. Such type of food chain operates in the decomposing accumulated litter in a temperate forest. A good example of detritus food chain (Fig. 3) is seen in a Mangrove (estuary). Mangrove leaf fragments acted on by **saprotrophs** (fungi, bacteria), colonized by algae are eaten by **detritus consumers** (crabs, shrimps, nematodes, molluscs etc.). These are in turn eaten by **minnows** and small carnivorous fish which serve as the food for large game fish and birds.

Thus the grazing food chain derives its energy from plants while in detritus food chain energy is obtained primarily from plant biomass, secondarily from microbial biomass and tertiarily from carnivores. Both the food chains occur together in natural ecosystems but the grazing food chain usually predominates.

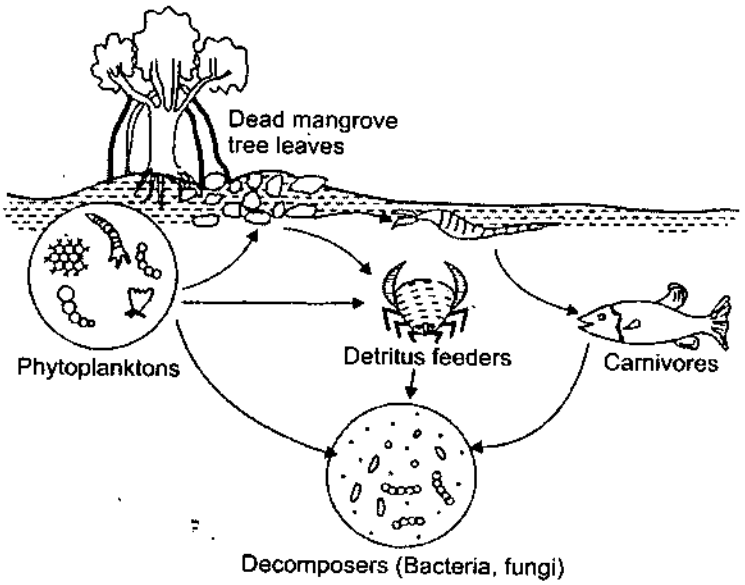


Fig. 3. A detritus food chain in an estuary based on dead leaves of mangrove trees.

(ii) Food Web–Interlocking Pattern of Organisms.

Food chains in ecosystems are rarely found to operate in isolated linear sequences. Rather, they are interconnected with several linkages forming a complex network of interlocking pattern which is referred to as **food web.** Thus, **food web is a network of food chains** where different types of organisms are

interconnected with each other at different trophic levels so that there are a number of options of eating and being eaten at each trophic level.

An example of food web is illustrated by the unique **Antarctic ecosystem** (Fig. 4). It is representing the total ecosystem including the Antarctic sea and the continental land. The land does not show any higher life forms of plants. The only species are that of some algae, lichens and mosses. The animals include snow petrel and penguins which depend on the aquatic food chain. In a tropical region, on the other hand, the ecosystems have a rich species diversity and therefore, the food webs are much more complex.

Why nature has evolved food webs in ecosystem instead of simple linear food chains? This is because food webs give greater stability to the ecosystem. In a linear food chain, if one species becomes extinct then the species in the subsequent trophic levels are also affected. Just consider the simple food chains of **Arctic Tundra** ecosystem.

Cladonia → Reindeer → Man

Grass → Caribou → Wolf

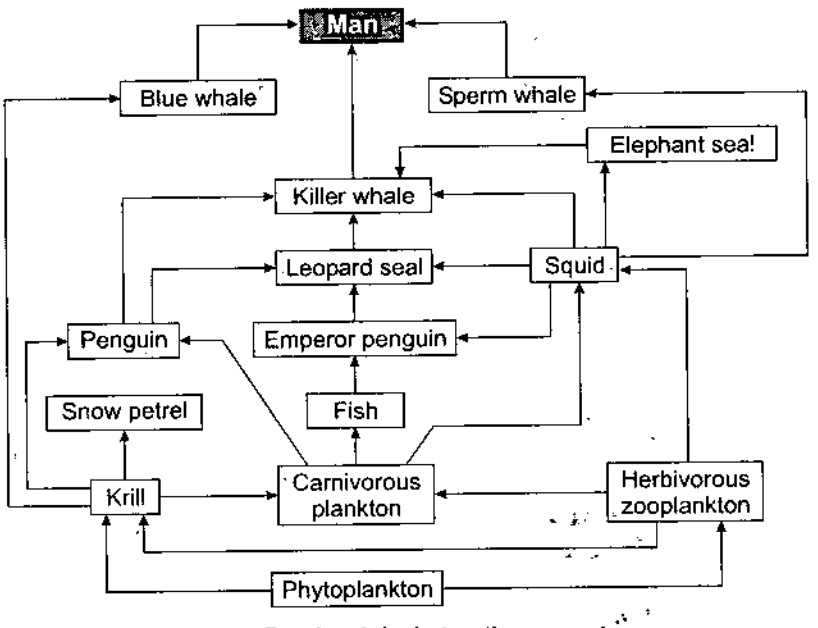


Fig. 4. Food web in Antarctic ecosystem.

If due to some stress, the population of reindeer or caribou falls, it will leave little option for man or wolf to feed from the ecosystem. Had there been more biodiversity, it would have led to complex food web giving the ecosystem more stability. In a food web, there are a number of options available to each trophic level. So if one species is affected, it does not alter other trophic levels so seriously. For instance, in grazing food chain of a grassland, in the absence of rabbit, grass may be eaten by mouse-which in turn may be eaten by hawk or snake **(Fig. 5.)**

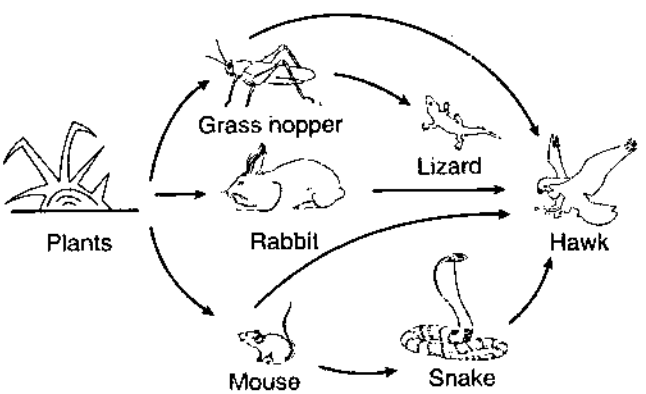


Fig. 5. Food web in a grassland ecosystem.

Besides those shown in Fig. 5, there may also be present some other consumers as vultures, fox and man in grasslands, and if so, the food web may be even more complex than shown here. In fact, real food webs usually have hundreds of species interlinked by their feeding habits.

Note. The complexity of any food web depends upon the diversity of organisms in the system. It would accordingly depend upon :

- **Length of the food chain.** More diverse the organisms in food habits, more longer would be the food chain.
- **Alternatives at different points** of consumers in the chain. More the alternatives, more would be the interlocking pattern.

Significance of Food Chains and Food Webs.

- Food chains and food webs play a very significant role in the ecosystem because the most important functions of **energy flow and nutrient cycling** take place through them.
- Food chains help in maintaining and regulating the **ecological balance.**
- Food chains show a unique property of biological magnification of several pesticides and heavy metals which are non-biodegradable in nature. Such chemicals increase in concentration at each successive trophic level.

ECOLOGICAL PYRAMIDS.

Graphic representation of trophic structure and function of an ecosystem, starting with producers at the base and successive trophic levels (herbivores → carnivores) forming the apex is known as **ecological pyramid.** These were first devised by British ecologist **Charles Elton** (1927) and so also known as **Eltonion pyramids.**

Ecological pyramids are of three types.

1. Pyramid of Numbers. It represents the number of individual organisms at each trophic level. There may be upright or inverted pyramid of numbers depending upon the type of ecosystem and food chain as shown in Fig. 6. A grassland ecosystem (Fig. 6a) and a pond ecosystem (Fig. 6b) show an **upright pyramid** of numbers. In **grassland,** the producers (grasses) are very large in number and form a broad base. The primary consumers (herbivores like rabbit, mice), secondary consumers (snakes, lizards etc.) and tertiary consumers (hawks or other birds) gradually decrease in number, hence the pyramid apex becomes narrower forming an upright pyramid. Similar is the case with **pond ecosystem.** Here the producers, mainly phytoplanktons such as algae and bacteria, are maximum in number. The carnivores (small fish, beetles etc.) and top carnivores (large fish) decrease in number at higher trophic levels forming an upright pyramid of number.

In a **forest ecosystem,** the producers are big trees which are less in number and hence form a narrow base. A large number of herbivores including birds, insects and several species of animals feed upon trees and form a much broad middle level. The secondary consumers like fox, snakes, lizards etc. are less in number than herbivores while top carnivores such as lion, tiger are still smaller in number. So the pyramid is spindle shaped, *i.e.*, narrow on both sides and broader in the middle (Fig. 6c).

Parasitic food chain shows an inverted pyramid of number. The producers like a few big trees harbour fruit eating birds acting as herbivores which are larger in number. A much higher number of lice, bugs etc. grow as ectoparasites on these birds while a still greater number of hyperparasites such as bugs, fleas and microbes feed upon them, thus making an **inverted pyramid** (Fig. 6d).

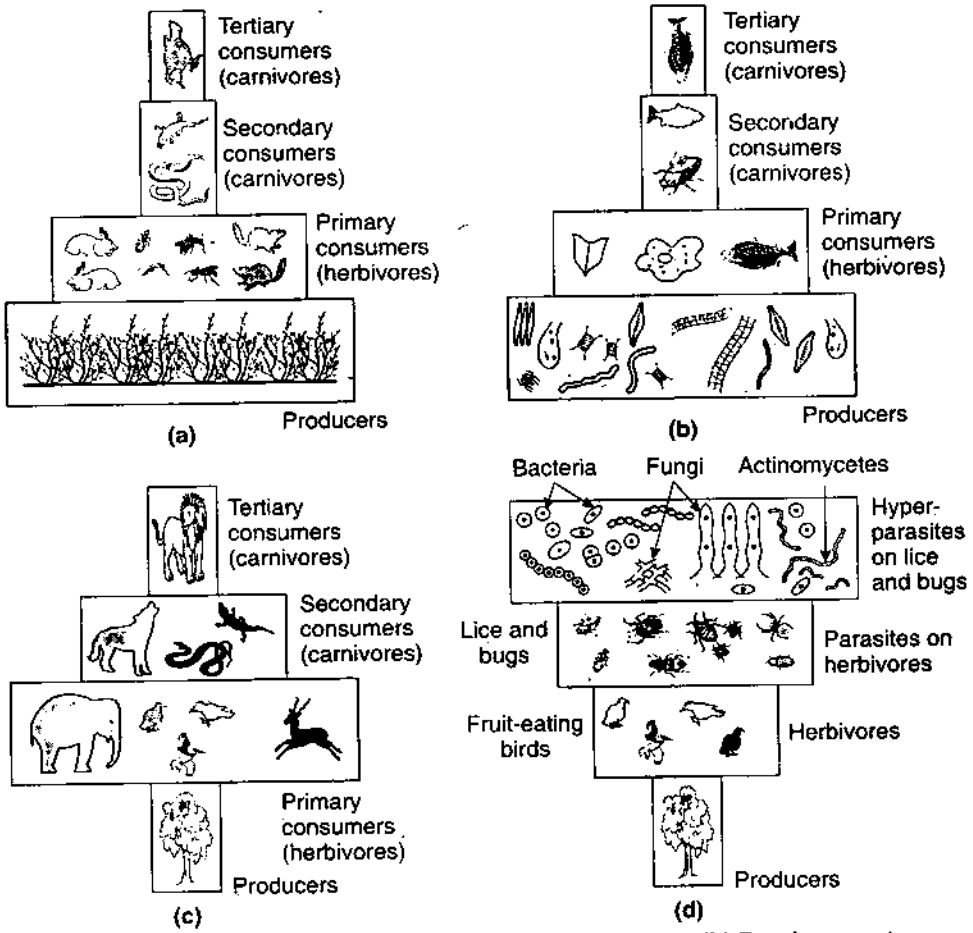


Fig. 6. Pyramid of numbers (a) Grassland ecosystem, (b) Pond ecosystem, (c) Forest ecosystem and (d) Parasitic food chain.

Note that the pyramid of numbers do not reflect a true picture of the food chain as they are not very functional. They do not indicate the relative effects of the geometry, food chain and size factors of the organisms. They vary with different communities with different types of food chains in the same environment.

2. Pyramid of Biomass. They are comparatively more fundamental since instead of geometric factor, they show quantitative relationships of the standing crops. Pyramid of biomass is based upon the total biomass (dry matter per unit area) at each trophic level in a food chain. In a **forest**, the pyramid of biomass is **upright** in contrast to its pyramid of numbers. This is because the producers (trees) accumulate a huge biomass while the consumers total biomass feeding on

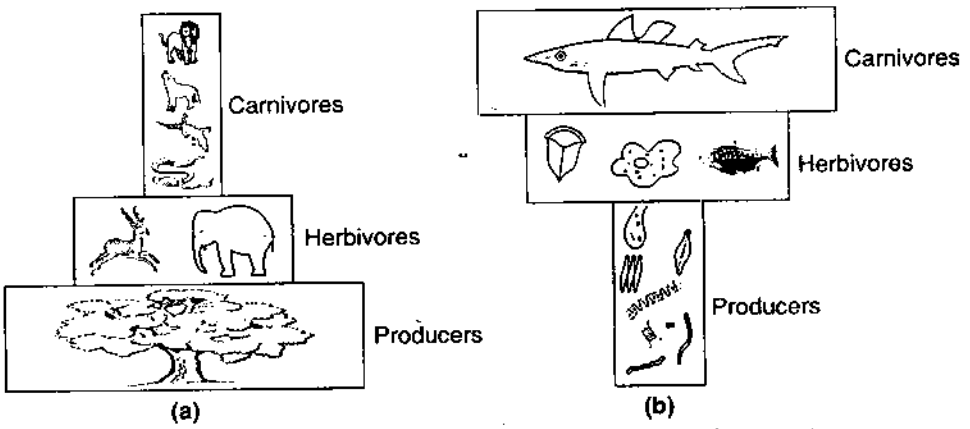


Fig. 7. Pyramid of biomass in (a) Forest and (b) Pond ecosystems.

them declines at higher trophic levels resulting in broad base and narrowing top (Fig. 7a). In a pond ecosystem, the total biomass of producers (phytoplanktons) is much less as compared to herbivores (zooplanktons, insects), carnivores (small fish) or tertiary carnivores (large fish). Thus the pyramid takes an inverted shape with narrow base and broad apex (Fig. 7b).

3. Pyramid of Energy. Pyramid of energy is based on the amount of energy trapped per unit time and area in different trophic levels of a food chain. **It gives the best representation of the trophic relationships and is always upright** (Fig. 8). The energy content is generally expressed as kJ/m²/yr. At each successive trophic level, there is sharp decline in energy (about 90% in the form of heat and respiration) as we move from producers to top carnivores. Thus only 10% of the energy passes on at each next higher level forming an upright pyramid.

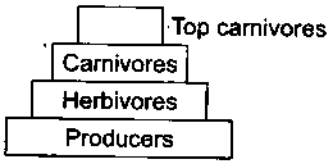


Fig. 8. Pyramid of energy in any ecosystem.

ENERGY FLOW IN AN ECOSYSTEM.

The functioning of ecosystem depends on the flow of energy through matter. The most important feature of energy flow is that it is **unidirectional** or one way flow. The energy captured by autotrophs does not revert back to solar input. Unlike nutrients (like C, N, P) which move in a cyclic manner and are reused by the producers after flowing through the food chain, energy is not reused in the food chain. Also the flow of energy follows the two laws of thermodynamics.

First law of thermodynamics states that energy can neither be created nor destroyed but it can be transformed from one form to another. The solar energy captured by the green plants (producers) gets converted into biochemical energy of plants and latter into that of consumers.

Second law of thermodynamics states that every transformation or transfer of energy is accompanied by its dispersion. As energy flows through the food chain, there occurs dissipation of energy at every trophic level. The loss of energy takes place through respiration or other metabolic activities. At every trophic level there is about 90% loss of energy and the energy transferred from one trophic level to the other is only 10%.

Energy Flow Models.

The flow of energy through various trophic levels in an ecosystem can be explained with the help of various energy flow models.

1. Single Channel Energy Flow Model. The flow of energy takes place in a unidirectional manner through a single channel of green plants or producers to herbivores and carnivores. Figure 9 depicts such a model and shows the gradual

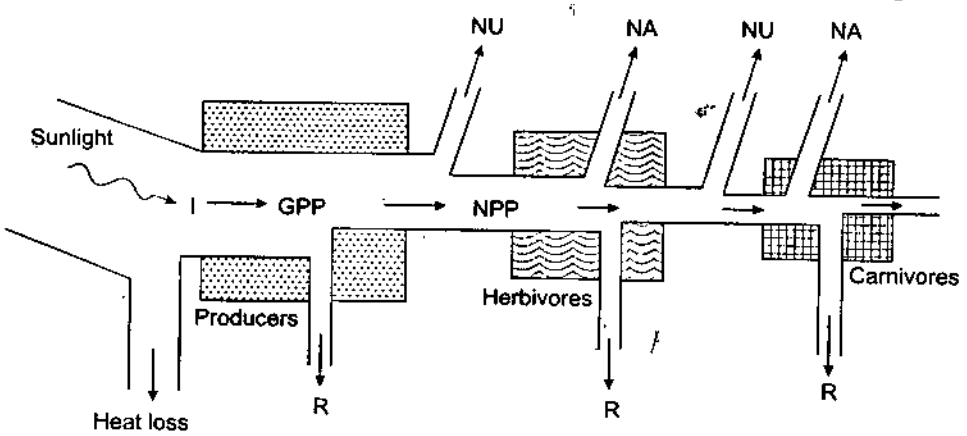


Fig. 9. One-way energy flow model (I = Solar energy input, GPP-Gross primary production, NPP– Net primary production, NU = Energy not used, NA = Energy not assimilated by consumers, e.g., excretion, R = Respiratory loss.)

decline in energy level due to loss of energy at each successive trophic level in a grazing food chain. Loss of energy is accounted largely by the energy dissipated as heat in metabolic activities and measured here as respiration coupled with unutilized energy. Thus shorter the food chain, greater would be the available food energy as with an increase in the length of food chain, there is corresponding more loss of energy.

2. Double Channel or Y-Shaped Energy Flow Model. In nature, both grazing food chain and detritus food chain operate in the same ecosystem (Fig. 10). But sometimes it is the grazing food chain which predominates. It occurs in

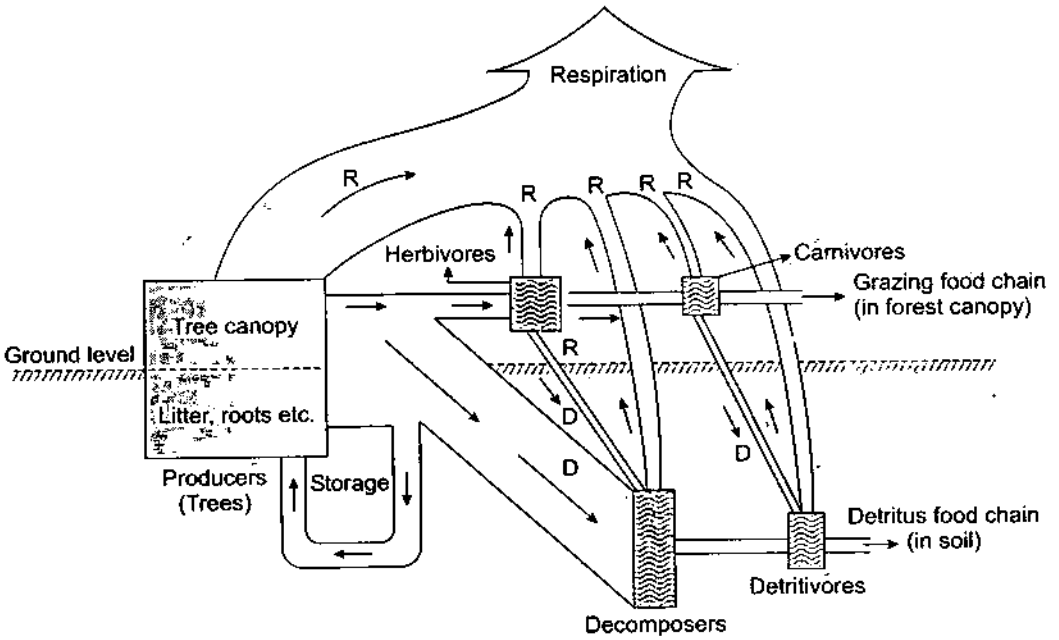


Fig. 10. Y-shaped or double channel energy flow model showing energy flow in grazing and detritus food chain (R = Respiration, D = Detritus or dead matter).

marine ecosystem where primary production in the open sea is limited and a major portion of it is eaten by herbivorous marine animals. Thus, very little primary production is left to be passed on to the dead or detritus compartment. In a **forest ecosystem,** on the other hand, the huge amount of biomass produced can not be completely consumed by herbivores. Rather, a large proportion of the biomass enters into detritus compartment in the form of litter. Hence here detritus food chain predominates. The Y-shaped or two channel model of energy flow shows the passage of energy through these two (grazing and detritus) food chains which are separated in time and space.

3. Universal Energy Flow Model. E.P. Odum explained energy flow through an ecosystem by the universal model (Fig. 11) applicable to living components like plant, animal, micro-organisms or a trophic group.

Such a model may depict food chain like single channel and Y-shaped energy flow systems. As the flow of energy takes place, there is a gradual loss of energy at every level, thereby resulting in less energy available at next trophic level as shown by narrower pipes (energy flow) and smaller boxes (stored energy in biomass). The loss of energy is mainly the energy not utilized (NU). This is the energy lost in respiration for maintenance or the energy lost in locomotion or excretion. Rest of the energy is used for production.

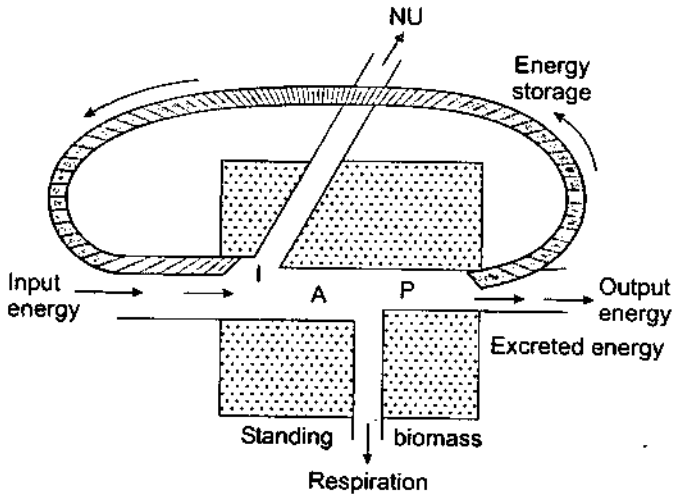


Fig. 11. Universal energy flow model (I = Input energy, A = Assimilated energy, NU = Energy not used, P = Production).

4. Multi-channel Flow of Energy. Multi-channel models indicate the basic pattern of energy flow in ecosystem. Under natural conditions, the organisms are inter-related in a way that several food chains become interlocked and this results into complex food web leading to multichannel flow of energy. In practice, under field conditions, we might face difficulties in measuring the energetics of ecosystem.

NUTRIENT CYCLING.

Nutrients like C, N, O, S, H, P etc., move in circular paths through biotic and abiotic components and so are called **biogeochemical cycles**. The nutrients too move through the food chain and ultimately reach the detritus compartment where various micro-organisms decompose organic nutrients of dead matter into inorganic substances that are readily used up by plants. Thus the cycle starts afresh.

PRODUCTIVITY.

The rate of organic matter or biomass production is called productivity. It is of two types.

(i) Primary Productivity. It is defined as the rate at which radiant energy is captured by producers for the synthesis of organic substances through photosynthesis or chemosynthesis. It is expressed as g m^{-2} $year^{-1}$ for dry matter and kcal m^{-2} $year^{-1}$ for energy. Primary productivity is further distinguished as :

(a) Gross primary productivity (GPP) is the rate of total production of organic matter/biomass by the producers per unit area and time.

(b) Net primary productivity (NPP) is the rate of organic matter stored by the producers after respiration (R) and maintenance per unit area and time.

$$\therefore \quad NPP = GPP - R$$

Primary production of an ecosystem depends upon the solar radiation, availability of water, nutrients, type of the plants and their chlorophyll content. Productivity of tropical forests and estuaries (20,000 kcal m^{-2} yr^{-1}) are the highest. Deserts on the other hand have limited water supply, hence show low primary production (200 kcal m^{-2} yr^{-1}).

Agro-ecosystems get lots of energy subsidies in the form of irrigation water, good quality seeds, fertilizers and pesticides and show high productivity of 12,000 kcal m^{-2} yr^{-1}. Still, their productivity is less than that of tropical forests which are

not receiving any artificial energy subsidies. Nature itself has designed its structure, species composition, rain fall, warm temperature congenial for growth, abundant sunlight, energy capture and flow and a closed nutrient cycling system that ensures their high productivity.

(ii) Secondary Productivity. The energy stored at consumer level (in excess of respiratory loss) for use by the next trophic level is known as secondary productivity.

• ECOLOGICAL SUCCESSION

An ecosystem is not static in nature. It is dynamic and undergo changes in structure as well as function with passage of time. It is observed that one type of community is totally replaced by another type of community over a period of time and simultaneously several changes occur leading to ecological succession. **Ecological or biotic succession is thus defined as an orderly process of changes in the community structure and function with time mediated through modifications in the physical environment and ultimately culminating in a stabilized ecosystem known as climax community.** It has maximum diversity and niche specialisation. The whole sequence of communities which are transitory are called **seral stages** or transitional communities while the community establishing first of all in the area is known as **pioneer community.** The entire series of communities of biotic succession from pioneer to climax community is called **sere.**

Ecological successions starting on a different types of areas or substrata are named differently as follows.

- **Hydrarch or Hydrosere.** Succession beginning on watery habitats such as ponds, lakes, swamp, marshes etc. are called **hydrarch** and the whole sequence of developmental stages constitutes **hydrosere.**
- **Mesarch.** This succession starts in an area of adequate moisture.
- **Xerarch or Xerosere.** It starts in dry habitats with little moisture. Xeroseres are of three types.
  - **(i) Lithosphere.** Sequence of successional stages on a bare rock.
  - **(ii) Psammosere.** Sequence of successional stages on sand.
  - **(iii) Halosere.** It starts on saline soil.

Characteristics of Ecological Succession.

- Ecological succession tends to progress from unstable community to stable biotic community.
- Its seral stages are regular and directional.
- In successive seral stages, there is tendency towards increase in species diversity, total biomass, niche specialisation and humus content of the soil.
- It tends to progress from simple food chains to complex food webs.
- Succession of plant and animal communities occurs side by side.

Types of Succession.

Depending upon the nudity of area, biotic succession is of two types.

1. Primary Succession. Primary succession occurs on a substratum devoid of earlier life, that is, bare rock, lava sediment, new island or pond. The sequence of successional stages of a primary succession is called **prisere.**

2. Secondary Succession. Secondary succession occurs in an area which have become bare due to destruction of previously existing biotic community by drought,

landslide or earthquake. The sequence of successional stages of secondary succession is called **subsere.**

Mechanism of Succession.

The process of succession takes place in a systematic order of sequential steps as follows.

1. Nudation. Nudation is the development of a bare area without any life form. The bare area may be caused due to volcanic eruption, landslide **(topographic factors)** or due to glaciers, drought, frost **(climatic factors)** or by overgrazing, disease outbreak, industrial or agricultural activities **(biotic factors).**

2. Migration or dispersal. The seeds, spores migrate to the bare area by air, water, wind, insects or birds. The first arrivals in a bare land are called pioneers or pioneer colonisers.

3. Ecesis or establishment. It is the successful establishment of a species as a result of adjustment with the conditions prevailing in the bare area.

4. Aggregation. Pioneer species reproduce, increase in number and form groups or aggregations.

5. Invasion. Pioneers of new species continue to reach the area under colonization. If they are able to establish in the new area, the process is called invasion and the new organisms are known as invaders.

6. Competition and coaction. As the number of individuals grows, there is competition both intra-specific (within the same species) and inter-specific (between different species) for space, water and nutrition. They influence each other in a number of ways, known as **coaction.**

7. Reaction. The living organisms grow, consume water and nutrients from the substratum, and in turn, they have a strong influence on the environment which is modified to a large extent and this is known as reaction. Sometimes, the modifications are such that they become unsuitable for the existing species and favour new species which replace them. Hence reactions lead to several **seral communities** or seral stages.

8. Stabilization. The succession ultimately culminates in a more or less stable community called **climax** which is in equilibrium with the environment. The climax community is characterized by maximum biomass and symbiotic (mutually beneficial) linkages between organisms and are maintained quite efficiently per unit of available energy. Consider following two types of succession.

SUCCESSION ON BARE ROCK (XERARCH).

Xerarch or Xerosere originates on bare rock which lacks water, nutrients and organic matter. The first inhabitants are usually lichens in temperate regions and cyanobacteria in tropical regions. The various stages that develop on bare rock are as follows.

1. Lichen stage. The pioneer community that grows on such substratum consists of crustose lichens like Graphis, Rhizocarpon and Lacanora. These lichens produce acids which disintegrate the rock and release minerals essential for their growth. Wind borne soil particles, humus and organic matter from dead lichens allows the growth of larger **foliose lichens** such as Parmelia, Physcia and Dermatocarpon. Foliose lichens retain more water, accumulate organic matter and develop a fine layer of soil on the rock surface.

2. Moss stage. The accumulation of soil, humus and organic matter favours the growth of mosses like Polytrichum, Grimmia, Bryum and Hypnum etc.

3. Herb stage. The mat formed by the decay of mosses on the partially fragmented rock become suitable for the germination of seeds of grasses such as Aristicla, Eleusine, Cymbopogon and Heteropogon etc.

4. Shrub stage. Due to further weathering of rocks, some xerophytic shrubs like Capparis, Rubus, Lizyphus etc. invade the area occupied by grasses. These shrubs cause further cracks in the rocky substratum resulting in the formation of soil rich in humus. This invites hardy trees and several types of animals.

5. Climax community. The climax community is a **forest** which depends on the climate. It is the rain forest in moist tropical area and a coniferous or deciduous forest in temperate area.

SUCCESSION IN A POND OR LAKE (HYDRARCH).

Hydrarch or hydrosere starts in a water body with phytoplanktons and following seral stages culminates to forest (Fig. 12).

1. Phytoplankton stage. The pioneer community consists of phytoplanktons which are free floating algae, flagellates, cyanobacteria and diatoms etc. Decomposed phytoplanktons mix with silt and form a soft mud at the bottom of pond which favour the growth of next seral stage.

2. Submerged stage. The submerged plants like Hydrilla, Utricularia, Potamogeton and Vallisneria etc. grow in mud and fill the water.

3. Floating stage. Growth of floating plants like Nymphea, Nelumbo, Azoila, Lemna and Pistia etc. keep on adding organic matter to the substratum by death and decay. Thus a layer of soil builds up and shallowing of water takes place.

4. Reed swamp stage. The amphibious plants such as Typha, Sagittaria, Scirpus etc. build up the shore and changes the substratum to a marshy soil.

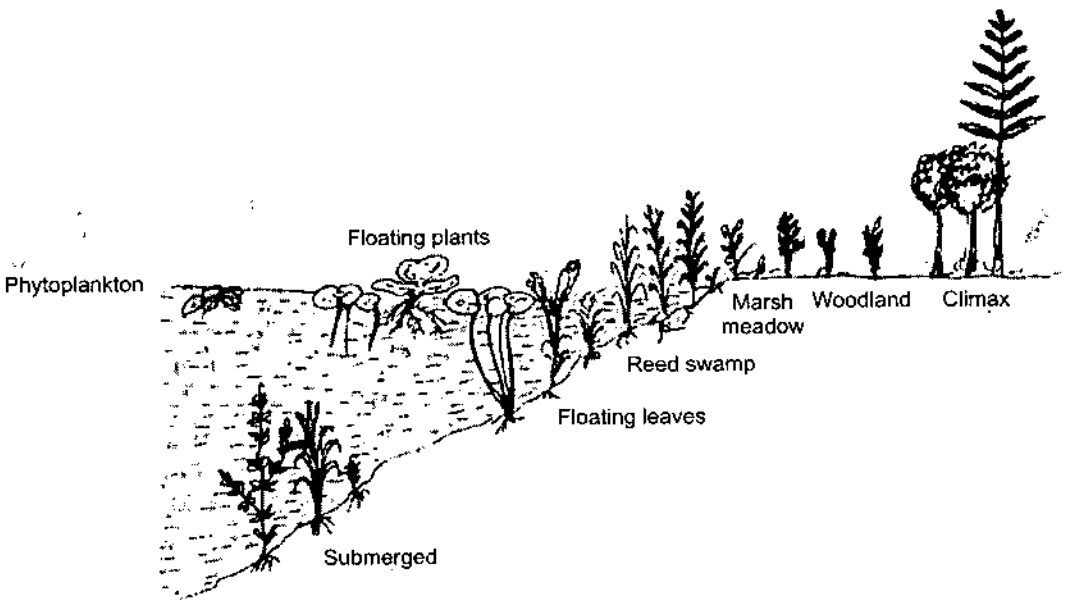


Fig. 12. Stages of plant succession in a pond or lake (Hydrarch).

5. Sedge or marsh meadow stage. The marshy shore of water body is invaded by Carex (sedge), Cyperus, some grasses like Themeda, Dicanthium and herbs such as Caltha and Polygonum etc.

6. Woodland stage. The periphery is inhabited by shrubs (Carnus, Cephalanthus) and some trees (Populus-cotton wood, Alnus).

7. Climax forest. Finally, the pond is covered by the climax community—the forest representing a terrestrial ecosystem.

• MAJOR ECOSYSTEMS

There are various types of ecosystems operating as self-sufficient interacting systems in the biosphere. For example, pond, lake, river, stream, spring, estuary, sea, desert, grassland, forest, coral reef, cropland (field of maize, wheat, sugarcane, paddy) etc. operate as individual ecosystem of nature. Although, all these ecosystems have more or less similar fundamental plan of their gross structure and function, however, they differ in respect of their species composition and rates in production etc.

• GRASSLAND OR TERRESTRIAL ECOSYSTEM

Grasslands are dominated by grass species but sometimes allow the growth of few trees and shrubs. Rainfall is average but erratic. Limited grazing helps to improve the net primary production of grasslands but overgrazing leads to desertification. Tropical (Savannas), temperate and polar grasslands are found to occur in different climatic regions.

Abiotic Components.

These are the nutrients present in soil and the aerial environment. Thus the elements like C, H, O, N, P, S etc., are supplied by carbon dioxide, water, nitrates, phosphates and sulphates present in air and soil of the area.

Biotic Components.

1. Producers. They are mainly grasses as species of *Dichanthium, Cynodon, Desmodium, Digitaria, Dactyloctenium, Brachiaria, Setaria, Sporobolus* etc. Besides them a few herbs and shrubs also contribute to primary production.

2. Consumers. Consumers occur in the following sequence :

Primary consumers. The herbivores feeding on grasses are mainly grazing animals such as cows, buffaloes, deers, sheep, rabbit, mouse etc. Besides them, there are also present some insects as *Leptocorisa, Dysdercus, Oxyrhachis, Cicincella, Coccinella,* some termites and millipeds etc., that feed on the leaves of grasses.

Secondary consumers. These are the carnivores like fox, jackals, snakes, frogs, lizards, birds etc. that feed on herbivores.

Tertiary consumers. Hawks feed on the secondary consumers.

3. Decomposers. The microbes active in the decay of dead organic matter of different forms of higher life are fungi, as species of *Mucor, Aspergillus, Penicillium, Cladosporium, Rhizopus, Fusarium* etc., some bacteria and actinomycetes. They bring about the minerals back to the soil, thus making them available to the producers.

• FOREST ECOSYSTEM

Forests are natural plant communities with dominance of trees. In India, the forests occupy 19% of the total land area. The major forest biomes are : tropical rain forests, tropical deciduous forest, temperate broad leaf or coniferous forest. Components of a forest ecosystem are :

Abiotic Components.

These are the inorganic and organic substances present in the soil and atmosphere. In addition to the minerals we find the dead organic debris—the litter accumulation. Climatic conditions (temperature, light, rainfall) are different due to complex stratification in the plant communities.

Biotic Components.

1. Producers. These are mainly trees that show greater degree of stratification especially in tropical moist deciduous forests. Beside trees, there are also present shrubs and a ground vegetation. In these forests, dominant members of the flora are *Tectona grandis, Butea frondosa, Shorea rubusta and Lagerstroemia parvifiora.* In temperate **deciduous forests**, the dominant trees are species of *Quercus, Acer, Betula, Thuja, Picea.* In temperate **coniferous forests**, the producer trees are species of *Abies, Picea, Pinus, Cedrus, Juniperus, Rhododendron* etc. while shrubs and ground flora are insignificant.

2. Consumers.

Primary consumers. These are the herbivores that include the animals feeding on tree leaves as ants, flies, beetles, leaf hoppers, bugs and spiders etc., and larger animals grazing on shoots and/or fruits of the producers like elephants, nilgai, deer, moles, squirrels, shrews, flying foxes, fruit bats, mongooses etc.

Secondary consumers. These are the carnivores like snakes, birds, lizards, fox etc., feeding on the herbivores.

Tertiary consumers. These are the top carnivores like lion, tiger etc. that eat carnivores of secondary consumer's level.

3. Decomposers. These are micro-organisms including fungi (species of Aspergillus, Fusarium, Alternaria, Trichoderma etc.), bacteria (species of Bacillus, Clostridium, Pseudomonas) and actinomycetes (species of streptomyces etc).

• DESERT ECOSYSTEM

Deserts occupy about 17% of land, occurring in the regions with an annual rainfall of less than 25 cm. The species composition of such ecosystem is varied and typical due to extremes of both, temperature and water factors. The various **biotic components** are :

1. Producers. These are shrubs, especially bushes, some grasses and a few trees. Sometimes a few succulents like cacti are also present. Some lower plants like lichens and xerophytic mosses may also be present.

2. Consumers. These are reptiles and insects, nocturnal rodents, birds and the **ship of desert,** camels.

3. Decomposers. These are very few, as due to poor vegetation the amount of dead organic matter is correspondingly less. These are some fungi and bacteria, most of which are thermophilic.

• AQUATIC ECOSYSTEM

POND OR LAKE OR FRESH WATER ECOSYSTEM.

A pond or a lake exhibits a self-sufficient, self-regulating ecosystem. Pond is a place where living organisms (plants and animals) live and create physico-chemical environment.

Abiotic Components.

The chief abiotic components are heat, light, pH value of water, inorganic and organic compounds such as water itself, CO_2 gas, C, H, O, N, P, Ca, S, carbohydrates, proteins, humic acid etc. Some proportions of nutrients are in solution state but most of them are present as stored in particulate matter as well as in living organisms. The amount of the minerals present at any time in the physical environment of the pond is called **standing state.**

Biotic Components.

1. Producers. These are autotrophic, green plants and some photosynthetic bacteria. Producers are of two types :

(i) Macrophytes. These are mainly rooted larger plants which include submerged, floating and emergent hydrophytes. The common plants are the species of *Trapa, Typha, Sagittaria, Potamogeton, Chara, Hydrilla, Utricularia, Marsilea, Nelumbo* etc. Besides them some free-floating forms as *Azolla, Salvinia, Wolffia, Eichhornia, Spirodella, Lemna* etc. also occur in the pond.

(ii) Phytoplanktons. These are minute, floating or suspended lower plants. Majority of them are filamentous algae such as *Zygnema, Ulothrix, Spirogyra, Cladophora* and *Oedogonium*. Besides them there are also present Chlorococcales, *Closterium, Cosmarium, Eudorina, Pandorina, Pediastrum, Scendesmus, Volvox, Diatoms, Anabaena, Gloeotrichia, Microcystis, Oscillatoria, Chlamydomonas, Spriulina* etc., and some flagellates.

2. Consumers.

(a) Primary consumers (Herbivores). These are :

- **Benthos (Detritivores).** Benthic populations include fish, insect larvae, beetles, mites, molluscs, crustaceans etc. They feed on plant remains lying at the bottom of pond.
- **Zooplanktons.** These are chiefly the rotifers as *Brachionus, Asplanchna, Lecane* etc., although some protozoans as *Euglena, Coleps, Dileptus* etc., and crustaceans like *Cyclops, Stenocypris* etc. are also present. They feed on phytoplanktons.

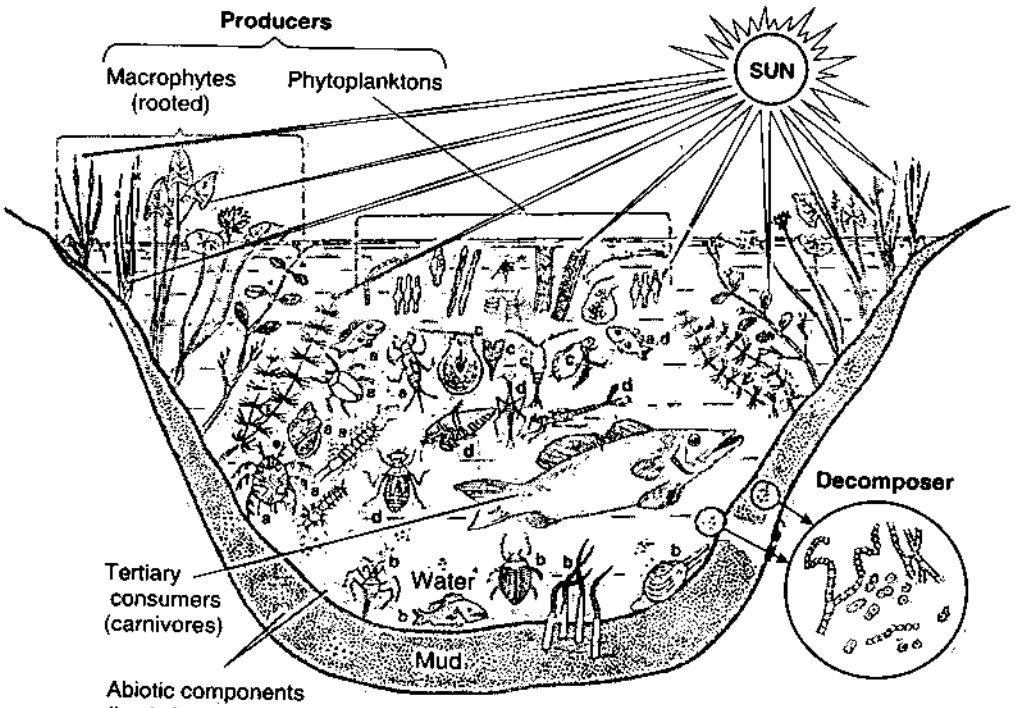


Fig. 13. Pond ecosystem showing its basic structural units.

(b) Secondary consumers (Carnivores). These carnivores (insects and fish) feed on the herbivores. Most insects as water beetles feed on zooplanktons.

(c) Tertiary consumers (Carnivores). The large fish as game fish that feed on the smaller fish become the tertiary (top) consumers.

3. Decomposers (Microconsumers). Decomposers include a variety of heterotrophic microbes that are osmotrophs. They are chiefly bacteria, actinomycetes and fungi like *Aspergillus, Cephalosporium, Cladosporium, Pythium, Rhizopus, Penicillium, Thielavia, Alternaria, Trichoderma, Circinella, Fusarium.*

RIVER OR STREAM AQUATIC ECOSYSTEM.

Rivers are large streams that flow downward from mountain highlands and flowing through the plains fall into the sea. Rivers have large surface area exposed to air and constant motion which churns the water and provide abundant oxygen. The various components are :

Abiotic Components.

Rivers have lots of silt rich in nutrients which is deposited in the plains and in the delta.

Biotic Components.

1. Producers. Producers are periphytons, attached algae, aquatic grasses in the slow moving water of banks.

2. Consumers. Consumers include fishes, leeches, snails, crocodiles. Many birds and mammals also get their food from rivers.

3. Decomposers. Several bacteria and fungi represent this group.

• ESTUARINE ECOSYSTEM

An estuary is a partially enclosed coastal area at the mouth of a river where fresh water and salty sea water meet. These are the transition zones which are strongly affected by tidal action. Coastal bays, river mouths and tidal marshes are examples of estuaries. Estuaries, the highly productive ecosystems, have a rich biodiversity and many of the species are endemic.

Abiotic Components. The river flow and tidal action provide energy subsidies for the estuary so it is rich in nutrients and food.

Biotic Components. Producers. These are macrophytes, benthic algae and phytoplanktons.

Consumers. Consumers are oysters, crabs, shrimps, fishes like eals and salmons. Organisms present in estuaries show a wide range of tolerance to temperature and salinity and are known as **eurythermal** and **euryhaline**. Estuaries are of much use to man so these ecosystems need to be managed judiciously and protected from pollution.

• OCEAN OR MARINE ECOSYSTEM

Oceans are gigantic reservoirs of water covering about 80% of the earth surface. These are the major sinks of CO_2 and play a key role in regulating many biogeochemical cycles and hydrological cycle, thereby maintaining the earth's climate.

Abiotic Components.

Marine water has high concentration of salts, mineral ions (Fe, Mg, P), natural gas, sand and gravel.

Biotic Components.

1. Producers. Producers include phytoplanktons (diatoms) and marine plants like sea weeds and angiosperms.

2. Consumers. These are crustaceans, molluscs and fishes.

3. Decomposers are mainly bacteria and fungi.

• QUESTIONS

1. What are the biotic and abiotic components of an ecosystem?
2. Discuss significance of food chains and food webs.
3. Why some of the ecological pyramids are upright while others are inverted in different ecosystems?
4. Explain the models of energy flow in an ecosystem.
5. Define productivity. Why are tropical wet forests and estuaries most productive?
6. Discuss mechanism of ecological succession.
7. State salient features of an aquatic ecosystem.

SHORT ANSWER QUESTIONS

1. *Define ecosystem?*
   Ans. Ecosystem may be defined as a structural and functional unit of biosphere consisting of biotic community and abiotic environment both interacting and exchanging energy and matter with each other. An ecosystem (open system) thus represents the highest level of ecological integration where interaction between living and non-living components is conducted by energy flow (solar energy) and cycling of materials between them.
2. *State major components of an ecosystem?*
   Ans. The major components are **abiotic** (non-living) and **biotic** (living) component. From the **trophic** (nutritional) stand point, an ecosystem has **autotrophic** and **heterotrophic** components.
3. *Define trophic level and standing crop?*
   Ans. The trophic structure of an ecosystem is a kind of producer-consumer arrangement where each food level is known as **trophic level**. The amount of living material in different trophic levels or in a component population is known as **standing crop.**
4. *Name the biggest flower in the plant kingdom.*
   Ans. Rafflesia arnoldi (7 kg weight) is the biggest flower. It is known to smell like rotten meat and attracts beetles, flies which help in its pollination.
5. *What are ecological pyramids?*
   Ans. Ecological pyramids devised by Charles Elton (so also called Eltonion pyramids) are the graphic representation of ecological parameters like number of individuals or amount of biomass or energy present in various trophic levels of a food chain with producers at the base and carnivores at the apex.
6. *What is meant by the heart of ecosystem dynamics?*
   Ans. The two ecological processes of energy flow and mineral cycling involving interaction between the physico-chemical environment and the biotic communities are considered as heart of the ecosystem dynamics.
7. *What is food web?*
   Ans. A net work of food chains which are interconnected at various trophic levels so as to form a number of different feeding connections among organisms in an interlocking pattern is called food web.

8. *How do the various ecosystems differ?*
Ans. Although all the ecosystems (*e.g.*, pond, lake, river, stream, sea, estuary, grassland, desert, coral reef, cropland) have more or less similar fundamental plan of their gross structure and function but they differ in respect of their species composition and rates in production etc.

9. *List major functional attributes of an ecosystem.*
Ans. Major functional attributes of an ecosystem are :
(i) Trophic structure, food chains and food webs.
(ii) Energy flow.
(iii) Cycling of nutrients (Biogeochemical cycles).
(iv) Primary and secondary production.
(v) Ecosystem development and regulation.

10. *How the double chain or Y-shaped model is more realistic working model than the single chain model?*
Ans. Because double chain model :
(i) Conforms to the basic stratified structure of ecosystems,
(ii) Separates grazing and detritus food chains,
(iii) Shows that the microconsumers (bacteria, fungi) and macroconsumers (phagotrophic animals) differ greatly in size-metabolism relations.

MULTIPLE CHOICE QUESTIONS

1. The most stable ecosystem is
(a) Ocean (b) Forest (c) Desert (d) Mountain

2. An abiotic component of the ecosystem is
(a) Bacteria (b) Humus (c) Plants (d) Fungi

3. The food chain in which micro-organisms feed on dead producers is called
(a) Consumer food chain (b) Predator food chain
(c) Detritus food chain (d) Parasitic food chain

4. The straight ecological pyramid is
(a) Pyramid of energy (b) Pyramid of biomass
(c) Pyramid of numbers (d) All

5. Food chains play very significant role in the ecosystem because
(a) Energy flow and nutrient cycling take place through them
(b) Of unique property of biological magnification
(c) They maintain ecological balance
(d) All

6. Gross primary productivity is highest in
(a) Grass lands (b) Wet tropical forests
(c) Agro ecosystem (d) Open oceans

7. The type of succession occurring on a bare rock is called
(a) Xerosere (b) Hydrosere (c) Halosere (d) Mesosere

8. A thick layer of ice found frozen under the soil surface through out the year is called
(a) Ice berg (b) Permafrost (c) Pampas (d) Steppers

9. The ultimate stable and culminating community in hydrarch and xerarch is
(a) Reed swamp (b) Woodland (c) Forest (d) Lichen

10. Estuaries have
(a) Fresh and salt-water (b) Rich biodiversity
(c) High productivity (d) All of these

FILL IN THE BLANKS

1. The term ecosystem was proposed by ..... .
2. ..... feed on both plants and animals.
3. The sequence of eating and being eaten in an ecosystem is known as ..... .
4. Pyramid of ..... is always upright.
5. The most important feature of energy flow is that it is ..... .
6. The energy stored at consumer level for use by the next trophic level is defined as ..... .
7. The whole sequence of communities which are transitory are known as .....
8. The succession ..... originates on a bare rock.
9. The lakes show ..... based on temperature difference.
10. ..... cling to other plants.

TRUE OR FALSE

1. Ecology is often defined as the study of ecosystems.
2. Detritivores are also known as saprotrophs.
3. Energy flow and nutrient cycling take place only through food web.
4. Graphical representation of trophic structure and function of an ecosystem is known as an ecological pyramid.
5. Orchids are epiphytes found in abundance in temperate deciduous forests.

ANSWERS

Multiple Choice Questions.

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

Fill in the Blanks.

1. A.G. Tansley
2. Omnivores
3. Food chain
4. Energy
5. Unidirectional
6. Secondary production
7. Seral stages
8. Xerosere
9. Stratification
10. Periphytons

True or False.

1. True 2. True 3. False 4. True 5. False

UNIT

3

ENVIRONMENTAL POLLUTION AND GLOBAL ENVIRONMENTAL ISSUES

STRUCTURE

• INTRODUCTION

The word pollution derived from the latin word **pollution** (meaning to defile or to make dirty) is the unfavourable alteration of our environment largely because of human activities. Pollution may be defined in various ways.

- *Pollution, the nuisance or nemesis, is the deliberate or accidental contamination of environment with the animal's waste.*
- *Pollution is an undesirable change in physical, chemical or biological characteristics of air, water and soil that may harmfully affect man, animal and the plant life, industrial progress, living conditions and cultural assets.*

[National Academy of Science, USA]

- *Pollution is the accumulation of any foreign material which may be organic, inorganic, biological or radiological in nature that may affect living organisms directly or indirectly, immediately or after a long time.*

[National Environmental Research Council]

Pollution of environment is one of the most horrible ecological crisis to which we are subjected today. Sometimes in the past the basic amenities— air, water and soil were pure, virgin, undisturbed, uncontaminated and basically most hospitable for living organisms. But the situation is just the reverse today, because of increased human activities following the progress in science and technology causing pollution of environment and serious ecological imbalance. **Environmental pollution is actually the result of urban-industrial-technological revolution and speedy exploitation of every bit of natural resources.**

• AIR POLLUTION

The atmosphere is a dynamic system, which steadily absorbs various pollutants from natural and anthropogenic sources. It is very difficult to get clean air today. **Clean air** is defined as *air occurring in areas sufficiently distant from places of human activities and other abnormal influences.* The World Health Organisation

(WHO) defined air pollution *as limited to situations in which the outer ambient atmosphere contains materials in concentrations which are harmful to man and his environment.* According to U.S. Public Health Service, air pollution may be defined as the presence of contaminants, such as fumes, dust, mist, grease, smoke or vapour in air which may be injurious to living biota.

• MAJOR CAUSES OF AIR POLLUTION

Air pollutants are substances causing damage to target or receptor. The target may be man, animal, plant, tree, building or material which is affected by pollutants. The air pollutants may be grouped according to the type of source, number and spatial distribution of sources and type of emissions.

A. Natural Sources. The natural sources of air pollution are volcanic eruptions and gases, forest fires, marsh gases, deflation of sands and dust, pollen grains of flowers, soil debris, cosmic dust, natural organic, inorganic or vegetative decay, extra terrestrial bodies, smoke, terpenes from forests and comets etc. Green plants through evapotranspiration release huge amount of CO_2. Micro-organisms such as algae, fungi, bacteria, yeast, moulds, spores are transported by wind to distant places causing air pollution.

B. Anthropogenic or Man made Sources.

1. Increase in Population. The rapid increase in population is one of the most important factor of air pollution. World population has touched 6.3 billion in the year 2010 and it will grow to 22.5 billion by 2100. An increase in population leads to global warming, loss in forest cover and wild life species.

2. Deforestation. Indiscriminate cutting of plants, trees and forest has disturbed the balance of CO_2 and O_2 in nature. Forests are also removed to meet the growing demands of population. The world produced 399 million tonnes of paper in 2009 and is losing 23 million hectares of forest cover each year. Developed countries use more than 71% of the world's paper production. By 2012, Asia would be the largest producer of paper.

3. Burning of Fossil Fuels. About 97% of the energy is generated by fossil fuels like coal, oil and natural gas. The major fuel burning sources are automobiles, thermal power plants, heating plants and industrial processes. Burning of fossil fuels produce about 2/3 of SO_2 present in air. It is the fourth largest source of air pollution.

4. Vehicular Emissions. The automobile exhausts are responsible for more than 75% of total air pollution due to the release of toxic gases such as CO(77%), NO_x (8%), hydrocarbons (14%) and particulates. Suspended particulate matter emitted by diesel contain highly carcinogenic polycyclic aromatic hydrocarbons (PAHs). Recently **nitrobenzthrone** (one such PAH) is analysed by Japanese scientists to be the worst carcinogen. 1,8-Dinitro- pyrene is a powerful mutagen known to exist in diesel.

5. Rapid Industrialisation. Next to combustion systems, the major sources of air pollutants are chemical and metallurgical industries.

6. Agricultural Activities. Several types of biocides such as pesticides, insecticides, herbicides etc. are used in agricultural practices which have caused soil erosion, ground water pollution and spread of pests resistant to pesticides in air. In global terms, **India** today has 16% of human population, 15% of farm animal population, 2% of the geographical area, 1% of rainfall, 0.5% of forests and 0.5% of grazing land. A number of biocides such as DDT, BHC, aldrin, chlordane, endosulphan etc. are not easily biodegradable. These are absorbed by plants and create adverse effects on biotic components.

7. Metallic Contaminants. Industrial activities discharge toxic metals which are indestructible poisons to living biota. According to **International Register of Potentially Toxic Chemicals** of United Nations Environment Programme, there exists six million known chemicals in the world today and 30,000 new compounds are added to the list every year. About 70,000 compounds are commonly employed.

8. Wars. Air pollution is caused by various types of sophisticated explosives used in wars. Radioactive rays emanated from atomic reactors and nuclear explosions pollute the air extensively.

• CLASSIFICATION OF AIR POLLUTANTS

The variety of matter emitted into the atmosphere by natural and anthropogenic sources is so diverse that it is difficult to classify air pollutants neatly. However, they are classified in different ways as follows :

A. According to Origin.

1. Primary Pollutants are directly emitted from the sources into the atmosphere. Typical pollutants included under this category are :

(i) Inorganic gases such as SO_2, NO_x, H_2S, CO, NH_3, CO_2, HF.

(ii) Particulate matter like ash, smoke, dust, fumes, mist, spray.

(iii) Olefinic and aromatic hydrocarbons.

(iv) Radioactive compounds.

2. Secondary Pollutants are those which are derived from the primary pollutants due to chemical or photochemical reactions in the atmosphere. Pollutants such as SO_2, NO_2, O_3, sulphate and nitrate salts, aldehydes and peroxyacetyl nitrate (PAN) are included in this category.

B. According to Chemical Composition.

1. Inorganic Pollutants include

(i) Nitrogen compounds (NO_x , NH_3).

(ii) Sulphur compounds (H_2S, SO_2, SO_3, H_2SO_4).

(iii) Carbon compounds (CO, carbonates).

(iv) Halogen compounds (HF, HCl, fluorides).

(v) Oxidising agents like ozone.

(vi) Inorganic particles such as silica, asbestos, flyash, dust etc.

2. Organic Pollutants are hydrocarbons, ketones, alcohols etc.

C. According to State of Matter.

1. Gaseous pollutants,
2. Particulate pollutants,
3. Aerosols,
4. Metallic components,
5. Radioactive pollutants,
6. Carcinogens,
7. Pesticides,
8. Biological contaminants.

• GASEOUS POLLUTANTS

NITROGEN OXIDES, NO_x.

The oxides of nitrogen, denoted by NO_x are N_2O, NO, NO_2, N_2O_3, N_2O_5. The atmospheric background concentrations are : **N_2O** (0.25 ppm), **NO** (0.1 to 2 ppm) and **NO_2** (0.5 to 4 ppm).

Formation of NO_x. Formation of NO and its oxidation to NO_2 is favoured at high temperature.

$$N_2 + O_2 \overset{1210\text{–}1765^\circ C}{\rightleftharpoons} 2NO$$

$$2NO + O_2 \overset{1100^\circ C}{\rightleftharpoons} 2NO_2$$

These reactions occur inside the automobile engines so that the exhaust gases consist of NO_x. In air, NO_x is converted into nitric acid by natural processes.

$$NO_2 + O_3 \longrightarrow NO_3 + O_2$$

$$NO_3 + NO_2 \longrightarrow N_2O_5 \qquad \text{(Nitrogen pentoxide)}$$

$$N_2O_5 + H_2O \text{ (water vapour)} \longrightarrow 2HNO_3$$

Nitric acid is one of the constituents of acid rain. It is the temporary sink for NO_2 in the stratosphere.

Effects of NO_x on Human Health.

The effects of NO_x depend on the concentration, period of exposure and the solubility. The major oxides of nitrogen which affect human health are NO and NO_2.

- NO_2 is relatively insoluble and upon inhalation can reach the moisture filled alveoli of lungs. There it is converted to nitrous and nitric acids which are highly irritating and cause damage to lung tissues.
- Exposure towards 150 to 200 ppm of NO_2 results in Bronchiolitis fibrosa obliterans, emphysema and biochemical alterations in blood within 3 to 5 weeks.
- NO_2, being most toxic, is also known to be transformed in the lungs to **nitrosamines** which are carcinogenic. It is also transformed to methaemoglobin in the blood.
- Acute exposure to NO_2 creates an irritating effect on mucous membrane.
- Chronic exposure to NO_2 at 100 to 150 ppm causes immunological changes in man. There is also a higher prevalence of dermatitis, eczema and rashes in more polluted exhaust gases.
- About 500–600 ppm of NO_2 for 2 to 10 days results in pulmonary haemorrhage, bronchitis, lung cancer, pneumonia, gum inflammation.
- NO_2 poisoning results in silofilter's disease.

Effects of NO_x on Plants.

- The damage caused by NO_x pollutants is of several types like **necrosis** (dead areas on a leaf), **chlorosis** (reduction of chlorophyll), **epinasty** (downward curvature of leaf) and abscission (dropping of leaves).
- Higher concentrations of NO_2 (10–50 ppm) checks the metabolic activities and retard the photosynthetic activity in plants.

Effects of NO_x on Materials.

- NO_2 fades away dyes in clothes like cotton, rayon and viscose rayon.
- NO_2 along with hydrocarbons produces peroxides which combine with ozone to cause crack in rubber.
- NO_2, O_3 and hydrocarbons in sunlight form PAN and peroxy compounds responsible for **photochemical smog**.

SULPHUR OXIDES, SO_x.

Formation of SO_x. Combustion of sulphur bearing materials produces SO_2 accompanied by a little quantity of SO_3. This mixture is denoted as SO_x.

$$S + O_2 \rightarrow SO_2, \quad 2SO_2 + O_2 \xrightarrow{Soot} 2SO_3 \xrightarrow{H_2O} H_2SO_4 \longrightarrow \underset{\text{aerosol droplet}}{(H_2SO_4)_n}$$

Beside soot particles, ozone also oxidises SO_2 to SO_3.

$$SO_2 + O_3 \xrightarrow{-O_2} SO_3 \xrightarrow{H_2O} H_2SO_4 \longrightarrow (H_2SO_4)_n$$

Sulphuric acid is one of the constituents of acid rain. CS_2, COS, $(CH_3)_2S$ and sulphates are also serious pollutants.

Global emission of SO_2 per year from **natural sources** like biological decay (H_2S), sea spray and volcanic activity is 90, 40 and 5 million tonnes per year while from anthropogenic sources such as coal, petroleum, smelting, sulphur production is 92, 26, 14 and 2 million tonnes per year respectively.

Effects of SO_2 on Human Health.

SO_2 is considered as the most serious single air pollutant causing numerous health hazards. Epidemiological and toxicological studies indicate a link between SO_2 pollution and respiratory conditions like chronic bronchitis, bronchial asthma, pulmonary emphysema and lung cancer etc. The vulnerability to SO_2 pollution depends upon age, sex, general health, nutrition, pre-existing diseases, concurrent exposures, concentration, extent of exposure, temperature and humidity at the time of exposure. People who are very young and very old, people of poor health, smokers or people with asthma, coronary heart disease are usually more vulnerable.

- SO_2, a severe allergenic agent, aggravates existing respiratory diseases in man. Even healthy individuals experience broncho-constriction when exposed for a few minutes to SO_2 levels of 1.6 ppm.
- In highly polluted area, SO_2 may cause watery nasal discharge, sneezing, cough, dyspnoea and desqumation.
- **London or sulphurous acid smog** called the killer smog of January 1956 was formed when SO_2 level rose to 0.40 ppm. The mortality rate among aged persons increased from 130 to 180 per day.
- H_2SO_4 so formed from SO_2 lowers pH, impairs enzymatic functions and destroys various functional molecules. It leads to bronchial spasms, breathlessness, impaired pulmonary function, via., airway resistance, impaired lung clearance and increased susceptibility for infection.

Effects of SO_2 on Plants.

The extent of damage caused by SO_2 to plants depends upon the nature, concentration, time of exposure, stage of growth, soil and plant condition, relative humidity and the extent of sunlight.

- An exposure of 0.3 to 0.5 ppm of SO_2 for several days causes bleached spots, chlorosis, chronic injury to spinach and other leafy vegetables. Leaf pigments bleaches due to the conversion of chlorophyll-a to phecophytin-a.
- Photosynthesis is affected by O_3, SO_2 and PAN.

Effects of SO_2 on Materials.

- Paper absorbs SO_2 which is oxidised to H_2SO_4 causing the paper to become brittle and fragile.
- Petroleum refineries, craft paper mills, industries and smelters liberating SO_2 adversely affect the historic monuments.
- SO_2 causes erosion of building materials such as marble, limestone and slate etc. The rapid attack of H_2SO_4 on marble is known as **stone leprosy.**

$$CaCO_3 + H_2SO_4 \longrightarrow CaSO_4 + CO_2 + H_2O$$

$$CaCO_3 + SO_2 + \frac{1}{2}O_2 \longrightarrow CaSO_4 + CO_2$$

The $CaSO_4$ so formed on the surface of masonry is twice as bulky as $CaCO_3$ which looks leprous or diseased.

Effects of H_2S and Organic Sulphides.

- H_2S smells like rotton eggs. It causes nausea, headache, loss of apetite even at 5 ppm.
- An exposure to 150 ppm of H_2S causes conjunctivitis, irritation of mucus membrane. H_2S rapidly passes through alveolar membrane of lung and penetrates in blood causing death due to respiratory failure.
- H_2S reacts with lead paints to form lead sulphide producing black discolouration.
- Organic sulphides cause odour nuisance when present in minute concentrations.

CARBON MONOXIDE, CO.

CO is the major primary individual pollutant with a tonnage matching that of all other pollutants together. Global emission of CO from natural sources amounts to 3364 million tonnes per year. Anthropogenic sources of CO emission include : Transportation (70 MT/year), fuel combustion (1.6 MT/year), industrial processes (7.8 MT/year), solid waste disposal (7.8 MT/year), others (8.5 MT/year) accounting to 95.7 MT/year.

Formation of CO. CO is formed by incomplete combustion of fuel or carbon containing compounds.

$$2C + O_2 \longrightarrow 2CO$$

$$CO_2 + C \xrightarrow[\text{at high temperature}]{\text{In blast furnace}} 2CO, \qquad CO_2 \xrightarrow{\text{Dissociation}} CO + O$$

Sinks. Plants and soil micro-organisms act as the natural sink of CO and CO_2.

Effects of Carbon Monoxide on Human Health.

- All the gaseous pollutants cause severe damage to respiratory system but the adverse effects of CO are unique.
- CO, when inhaled, passes through the lungs and diffuses directly into the blood stream where it combines with the red blood corpuscles of haemoglobin (Hb) forming carboxy haemoglobin, COHb.

$$HbO_2 + CO \rightleftharpoons COHb + O_2$$

The affinity of CO for haemoglobin is 210 times greater than that of oxygen. As a result the amount of haemoglobin available for carrying oxygen for body tissues and lungs is considerably reduced. The body tissues are thus deprived of their oxygen supply and death could result by **asphyxiation** (lack of O_2). In addition, the **presence of COHb in the blood retards the dissociation of remaining oxyhaemoglobin** (HbO_2), so the tissues are further deprived of oxygen.

The **equilibrium level of COHb** may be estimated for concentration of CO below 100 ppm in the inhaled air by using the equation,

% of COHb in blood = 0.16 times the CO level in air +0.5.

- **Cigarette smokers** continuously have a COHb content about 5 to 10% in their blood. Smoke contains about 20,000 ppm of CO which is diluted to about 500 ppm during inhalation. In women it leads to premature births, spontaneous abortions, deformed babies and affects estrogen hormone.

- However, smoking provides immunity to **Parkinson's disease** which may be due to the release of pyridine in the body. It is most probably by competing with other toxins and blocking the impact on neuro-receptors.
- **CO poisoning can be cured** by exposing the affected person to fresh air whereby reverse reaction can occur.

$$COHb + O_2 \longrightarrow O_2Hb + CO$$

- Traffic policeman at busy street crossings during heavy traffic rush hours are advised to use oxygen tanks in developed countries. Vitamin C is capable of preventing upto 50% of the damage caused to white blood corpuscles in smokers.

Carbon dioxide causes green house effect or global warming.

Table. 1. Health effects of COHb blood levels.

COHb blood level (%) 1 to 2	Affects behavioural activities.
2 to 5	Heart patients may lack sufficient cardiac reserve to compensate.
5 to 9	Cardiac and pulmonary functional changes. Patients with angina pectoris require less excretion to induce chest pain.
10 to 20	Laboured respiration during exertion. Headache, reduced mental acuity. May be lethal for patients with severe cardiovascular disease.
20 to 30	Headache, nausea, visual acuity, angina, ECG changes.
30 to 40	Severe headache, nausea and vomiting, dizziness, fatigue.
40 to 50	Slurring of speech, tendency to collapse.
50 to 70	Convulsions, fatal coma if not treated.

Effects of CO on Plants.

- CO at higher levels (100 to 1000 ppm) causes leaf curling, leaf drop, reduced leaf size and interfere with cellular respiration.
- Nitrogen fixing ability of bacteria in clover roots is inhibited when exposed to CO levels of 2000 ppm for 35 hours.

HYDROCARBONS.

Natural sources, particularly trees emit large number of hydrocarbons. Methane, the major hydrocarbon, is produced by bacteria in the anaerobic decomposition of organic matter in water, sediments and soil.

$$2CH_2O \xrightarrow{\text{Bacteria}} CO_2 + CH_4$$

Global emission of methane is 1450 MT/year and that of terpenes is 170 MT/year. Domesticated animals contribute 85 MT/year methane to air. Global emission of hydrocarbons (*e.g.*, methane, ethane, benzene, hexane, xylene, benzo-α-pyrene etc.) from human activities is :

Petroleum (55%), coal (3.3%), wood (2.2%), solvent evaporation (11.3%), refuse burning (28.3%). Annual global emission is estimated to 57×10^7 tonnes per year.

Effects of Hydrocarbons on Human Health.

- Hydrocarbons like benzene, toluene and benzopyrene at 600 to 1000 ppm produce edema, headache, drowsiness and symptoms akin to drunkenness.
- Secondary pollutants such as peroxyacetyl nitrate (PAN) and peroxybenzoyl nitrate irritate nose, throat, eyes and cause chest constriction.
- Cyclic hydrocarbons affect respiratory system, nervous system, dilate pupil's of eyes, cause loss of coordination, affect DNA and cell growth.

- Higher levels of methane create narcotic effects on man. PAH cause synergistic effects.

Effects of Hydrocarbons on Plants.

- Hydrocarbons and photochemical oxidants are injurious to plants. **Ethylene** at 0.1 ppm for several hours cause epinasty, leaf abscission and flower dropping.
- Peroxyacetyl nitrate (0.01 to 0.05 ppm for a few hours) causes glazing or bronzing of underside of leaf, damages sensitive plants, young leaves, necrosis of leaf tip. Grapes are particularly susceptible to attack.

Effects of Hydrocarbons on Materials.

Hydrocarbons induce chemical alteration in paper, textile, rubber, polymers making them more brittle and fragile.

• PARTICULATES

Small solid particles and liquid droplets are collectively termed particulates. The number of particles in the atmosphere vary from several hundred per cm^3 in clean air to more than 100,000 per cm^3 in highly polluted air. Man made sources for particulate emission include flyash from power plants, smelters, fuel combustion, industrial operations, refuse burning etc. Every year natural sources discharge 800-2000 million tonnes and man made sources 200 to 500 million tonnes of particulates.

Effects of Particulate Matter on Human Health.

The toxic effects of particulates can be grouped into three categories :

1. Interference of inert particles with the clearing mechanisms of the respiratory tract. Dust, soot, smoke get deposited in pulmonary lymphatic depot points to create toxicity.
   - **Silicosis,** a chronic disease of lungs, is caused by inhalation of dust containing free silica.
   - Acrolein particles poses bronchio-constriction. Insoluble particulates which cannot be phagocytized by WBCs pass through the alveolar walls into lymph channels causing lung cancer.
2. Particulates act as carriers of adsorbed toxic gases such as SO_2 and produce synergistic effects.
3. Particulate matter may be intrinsically toxic because of their physical and chemical characteristics. A summary of some observed relations between particulates and SO_2 levels and the physiological responses is given in Table 2.

Table 2. Relation between particulates and SO_2 levels and health effects.

S.No.	Conditions	Effects
1.	Particulate level of 750 $\mu g/m^3$ with SO_2 at 715 $\mu g/m^3$ (0.25 ppm), both 24 hours mean.	Substantial increase in illness of persons with bronchitis. Increased daily death rate.
2.	Low particulate level with SO_2 levels ranging between 300 and 500 $\mu g/m^3$ (0.11–0.19 ppm) both 24 hours mean.	Respiratory diseases, increased absenteeism among older workers.
3.	Particulate level of 300 $\mu g/m^3$ with SO_2 level of 600 $\mu g/m^3$ (0.21 ppm), both 24 hours mean.	Worsening of symptoms in persons suffering from chronic bronchitis.

Effects of Air Pollutants on Animals.

Particulates, hydrocarbons, lead, arsenic and fluorides are the main pollutants which cause damage to livestock. These air-borne contaminants accumulate in vegetation, forage and poison the animals when they graze the contaminated vegetation.

Livestock near smelting and other industrial operations suffer arsenic poisoning with symptoms like salivation, thirst, liver necrosis, inflammation and depression of central nervous system.

Lead poisoning occurs in horses and other animals with symptoms such as lethargy, paralysis, depression, gastritis and breathing troubles.

• CONTROL MEASURES OF AIR POLLUTION

The most effective method of controlling air pollution is to prevent the formation of the pollutants or minimise their emission at the source itself. In case of industrial pollutants, this can be achieved by investing various approaches at an early stage of process design and development and selecting those methods which have minimum air pollution potential. These are known as **source correction methods.** Control of pollutants at the source can be accomplished in various ways through raw material change, operational changes, modification of process equipment and by more effective operation of existing process.

• CONTROL OF PARTICULATE EMISSION

Particulate matter emitted in gaseous streams consists of discrete and minute suspended particles. Particle size ranges generally from 100 μm down to 0.1 μm and even less. ***The choice of collection devices depends upon a number of factors:*** *the physical and chemical characteristics of particulates, the particulate size and concentration in the gas, volume of particulates to be handled and the temperature and humidity of gaseous medium. In particular, factors like toxicity and inflammability must be taken into consideration when evaluating operating efficiency.*

Basic Mechanisms. The basic mechanisms of removing particulate matter from gas streams may be classified as :

1. Gravitational settling
2. Centrifugal impaction
3. Inertial impaction
4. Direct interception
5. Diffusion and
6. Electrostatic precipitation.

Equipment presently available, which make use of one or more of the above mechanisms, fall into the following five broad categories :

1. Gravitational settling chambers
2. Cyclone separators
3. Fabric filters
4. Electrostatic precipitators and
5. Wet collectors (scrubbers).

The gravitational settling chambers and cyclone separators will not generally achieve high efficiencies for removing small size particles. For most practical application, only fabric filters, electrostatic precipitators and high energy scrubbers are capable of meeting the rigorous air pollution control regulations.

Electrostatic Precipitators for the Control of Particulate Emission.

The electrostatic precipitator is used for controlling particulate emissions at industrial installations ranging from power plants, cement and paper mills to oil refineries. ***Electrostatic precipitation is a physical process by which particles suspended in gas stream are charged electrically under the influence of electrical field and separated from the gas stream.***

The precipitation system consists of a positively charged (grounded) collecting surface and a high-voltage discharge electrode wire suspended from an insulator at the top and held in position by a weight at the bottom. At a very high DC voltage, of the order of 50 kV, a corona discharge occurs close to the negative electrode, setting up an electric field between the emitter and the grounded surface. The particle-laden gas enters near the bottom and flows upward. The gas close to the negative electrode is, thus, ionized upon passing through the corona.

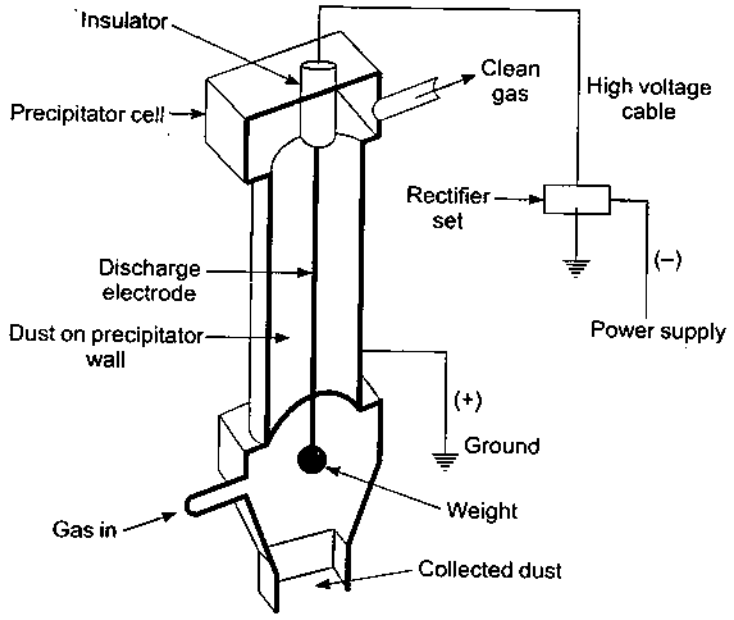


Fig. 1. Schematic diagram of a wire and pipe electrostatic precipitator.

As the negative ions and electrons migrate toward the grounded surface, they in turn charge the passing particles. The electrostatic field then draws the particles to the collector surface where they are deposited. Periodically, the collected particles must be removed from the collecting surface. This is done by vibrating the collector to dislodge the particles. The dislodged particles drop below the electrical treatment zone and are collected for ultimate disposal.

• CONTROL OF GASEOUS POLLUTANTS

CONTROL OF NITROGEN OXIDES POLLUTION.

NO_x emissions from stationary sources can be reduced by

- Minimising the residence time at peak temperature.
- Reducing the peak temperature.
- Minimising the availability of O_2 for reaction with N_2.

Effluent Gas Treatment Methods.

1. Scrubbing Methods.

(i) Absorption of NO_x by Liquids. For controlling NO_x emissions from power plants (200 to 1500 ppm), three processes have been proposed which partly improve the economics of SO_2 recovery also.

- Treatment with lime slurry where nitric acid and gypsum are recovered as the byproducts.
- Scrubbing with magnesium hydroxide liquor where concentrated NO is recovered as the byproduct.
- Absorption in sulphuric acid which produces both nitric and sulphuric acids.

All the three processes are complex and require attainment of equimolar concentrations of NO and NO_2 in the gas, since the absorption of the combined oxide, N_2O_3 is most favourable.

(ii) Adsorption of NO by Solids. The adsorbents used for oxidizing NO to NO_2 and for adsorbing nitrogen dioxide are activated carbon, silica gel, **molecular sieves, ion-exchange resins,** ferrous salt, manganese and alkalized ferric oxides.

2. Catalytic Decomposition

Catalytic reactions using Al_2O_3, Fe_2O_3, Co_3O_4 etc. involve decomposition of NO_x into N_2 and O_2.

3. Catalytic Reduction

Catalytic reduction is much better for controlling NO_x emissions because of the presence of reducing agents in the flue gas. The method is also used to control nitric acid emissions in tail gas. Catalysts used in the reduction of NO include Fe-chromite, Cr promoted FeO, supported copper chromite, Zn-promoted copper chromite.

Reduction process is of two types, *i.e.*, selective and non-selective. In **selective reduction,** the added reactant preferentially reduces NO_x and in **non-selective** reduction, the excess oxygen must be consumed first. Selective reduction is to be preferred since it minimises the amount of reactant required. Typical reactions are:

$$2NO + 2H_2 \longrightarrow N_2 + 2H_2O, \qquad 2NO + 2CO \longrightarrow N_2 + 2CO_2$$

$$6NO + 4NH_3 \longrightarrow 5N_2 + 6H_2O$$

In **non-selective reduction**, two types of reactions take place.

- Fuel reacts with O_2 and NO_2, the latter being reduced to NO.

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O, \quad CH_4 + 4NO_2 \longrightarrow CO_2 + 2H_2O + 4NO$$

- NO is reduced to N_2.

$$CH_4 + 4NO \longrightarrow CO_2 + 2H_2O + 2N_2$$

NO_x Removal from Stack Gas

It is performed by chemical sorption process using H_2SO_4 solution or alkaline scrubbing solution containing $Ca(OH)_2$ and $Mg(OH)_2$. Simultaneously, SO_2 is also removed. NO is converted into N_2O_3 which is easily absorbed.

$$NO_2 + NO \longrightarrow N_2O_3$$

NO_2 is recycled. This scrubbing process involves four steps.

(i) NO_2 and flue gas are introduced into an oxidiser.

$$NO_2 + SO_2 + H_2O \longrightarrow H_2SO_4 + NO$$

(ii) NO and NO_2 react to form N_2O_3 which is scrubbed by H_2SO_4 in a scrubber. The cleaned flue gas is released into the air.

$$NO_2 + NO \longrightarrow N_2O_3$$

$$N_2O_3 + 2H_2SO_4 \longrightarrow 2NOHSO_4 + H_2O$$

(iii) The reaction product from the scrubber is then decomposed in a decomposer and the resulting H_2SO_4 is recycled to the scrubber.

$$2NOHSO_4 + \frac{1}{2}O_2 + H_2O \longrightarrow 2H_2SO_4 + 2NO_2$$

(iv) NO_2 produces HNO_3 in the reactor.

$$3NO_2 + H_2O \longrightarrow 2HNO_3 + NO$$

Excess of NO_2 and NO are recirculated through the oxidiser in step (i).

CONTROL OF SO_x POLLUTION

Several approaches can be employed for the removal of SO_x pollution, such as, removal of SO_2 from fuel gases, sulphur reduction within the combustion chamber and using low sulphur fuels.

1. Desulphurization of Flue Gases

Dry Methods. The dry techniques for the desulphurization of flue gases may be classified as follows.

(a) adsorption of SO_2 by metal oxides to form stable sulphites or sulphates with subsequent regeneration of the oxide and recovery of sulphur and

(b) adsorption on activated carbon followed by regeneration and conversion of concentrated SO_2 to sulphuric acid or elemental sulphur.

2. Flue Gas Scrubbing Process

The Stone and Webster-Ionics Scrubbing Process. It is based upon the reaction of caustic soda (NaOH) solution with SO_2 to form sodium sulphite and bisulphite.

$$2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$$

$$Na_2CO_3 + SO_2 \longrightarrow Na_2SO_3 + CO_2$$

$$Na_2SO_3 + \frac{1}{2}O_2 \longrightarrow Na_2SO_4$$

$$Na_2SO_3 + SO_2 + H_2O \longrightarrow 2NaHSO_3$$

The resulting solution is treated with dilute H_2SO_4 to get sodium sulphate and concentrated SO_2 gas.

$$Na_2SO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + SO_2 + H_2O$$

$$2NaHSO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + 2SO_2 + 2H_2O$$

The heart of the process is the electrolytic regeneration cell which converts Na_2SO_4 into NaOH and H_2SO_4. The overall reaction is

$$Na_2SO_4 + 3H_2O \longrightarrow 2NaOH + H_2SO_4 + H_2 + \frac{1}{2}O_2$$

NaOH is returned to the absorber and the acid is used in the desorption tower.

3. Control of SO_2 Emission from Sulphuric Acid Plants

A contact plant operating on the single absorption principle at a conversion efficiency of 98% discharges about 2000 ppm of SO_2 in the tail gases.

(i) **The DCDA process** reduces the SO_2 emissions in the exit gases to a level of about 500 ppm and simultaneously increases the output of the acid by 1–2%.

(ii) In ammonia process, ammonia sulphite-bisulphite formed is reacted with nitric or orthophosphoric acid to produce the appropriate ammonium salt and SO_2 is recovered for further processing.

CONTROL OF CO POLLUTION

The petroleum and diesel fed automobiles account for major share (70%) of CO emission. Carbon monoxide is formed because of insufficient quantity of oxygen. CO, unlike other gaseous pollutants, cannot be removed by exhaust gas techniques. Hence the best way is to control its formation. This is however not easy because the control strategies for CO and NO_x are basically in conflict. The effective method of reducing CO emission from stationary combustion sources is by **proper design, installation, operation and maintenance of combustion equipment.**

CONTROL OF HYDROCARBONS

The techniques used to control hydrocarbon emissions from stationary sources include incineration, adsorption, absorption and condensation. Hydrocarbon removal efficiencies are high in the flame after burner. Some limitations of flame after burner are that it emits NO_x, CO and may require expensive heat recovery equipment.

Adsorption Method. The polluted gas stream is passed through granular activated carbon. The adsorbed vapours are usually removed by passing stream through the system. The mixture of steam and hydrocarbons is liquefied in a condenser and cooled. Hydrocarbons are recovered from the water.

Condensation Method. The method utilises the fact that at low temperatures, gaseous hydrocarbons condense to liquids. The effluent gas stream is passed over low temperature surfaces and the condensed hydrocarbons are left behind and collected. Ozone and PAN are secondary pollutants so their control ultimately depends on the control of hydrocarbons and NO_x.

• WATER POLLUTION

INTRODUCTION

Water is one of the most precious commodity required for the survival of any form of life. Today water resources have been the most exploited natural system since man strode the earth. Pollution of water bodies is increasing tremendously due to population explosion, industrial proliferations, urbanisations, increasing living standards and wide spheres of human activities. Time is, perhaps not too far when pure and clean water, particularly in densely populated and industrialised water scarce areas may be inadequate for maintaining the normal living standards.

Ground water, rivers, seas, lakes, ponds, streams are founding it more and more difficult to escape from pollution. In India, the major 14 rivers receive heavy flux of sewage, industrial effluents, domestic and agricultural wastes. Most of the large rivers of the world are nothing but open sewers fit only to carry urban wastes, poisonous pesticides and industrial toxic effluents etc. Many of our lakes, including **Dal and Nagin of Kashmir** have severely polluted with foul odour, silt deposits and get chocked due to excessive algal growths. Now pollution of water bodies has become universal phenomenon in the present day world.

Signs of Water Pollution. These are bad taste of drinking water, offensive odours from water bodies, unchecked growth of aquatic weeds in water, decrease in number of fish in fresh water, oil and grease floating on water surfaces. These factors disturb the normal uses of water for public water supply, aquatic organisms, agriculture and industry.

• DEFINITION OF WATER POLLUTION

Water gets polluted when its normal functions and properties are altered. Water pollution actually represents the state of deviation from the quality and purity of water sample.

- *Water pollution shows the addition of foreign substances, either from natural or anthropogenic sources, may be harmful to life because of their toxicity, reduction of normal oxygen level of water, aesthetically unsuitable and spread epidemic diseases.*
- *It is the natural or induced change in the quality of water which renders it unsuitable and toxic as regards food, man and animal health, industry, agriculture, fishing or leisure pursuits.*
- *Water pollution is the by product of rapid and unplanned industrial progress and over population.*
- *Any shift in the naturally dynamic equilibrium existing among environmental segments, i.e., hydrosphere, lithosphere, atmosphere or sediments give rise to the state of water pollution.*
- Water pollution may be in ground water, surface water, lake water, river or ocean water.

• CAUSES OF WATER POLLUTION

Today clean water has become a precious natural resource but its quality is threatened by numerous sources of pollutants which are as follows :

1. Inorganic Pollutants.

This category of water pollutants consists of acids, alkalies, soluble and insoluble salts, metallic complexes, trace elements, organometallic compounds, polyphosphatic detergents from chemical industries, metallurgical processes, coal mines and numerous natural processes causing pollution in water.

2. Toxic Metals.

Toxic metals are added in water from industrial activities, domestic sewage discharges, land run off and fossil fuel burning. Traces of heavy metals such as Hg, Cd, Pb, As, Co, Mn and Cr have been identified deleterious tc aquatic ecosystem and human health. In fish, mercury is present as $(CH_3)_2Hg$ which is known to concentrate in food chain. Manganese also enter the water system through industrial effluents and dry cell batteries. Selenium content of most drinking water is found as 10 ppb.

3. Organic Pollutants.

Organic pollutants enter into water system through domestic sewage, industrial wastes from paper mills and tanneries, waste from slaughter house, meat packing plants, plant nutrients, detergents, biocides etc. The addition of carbohydrates, fatty acids, proteins, aldehydes, polychlorinated biphenyls (PCBs), phenolic compounds and polycyclic aromatic hydrocarbons deteriorate water quality.

4. Sewage and Domestic Wastes.

Sewage is a cloudy dilute aqueous solution containing mineral and organic matter. About 75% of water pollution is caused by sewage, domestic wastes, food processing plants, garden wastes and sewage sludge from cess pools etc. Sewage contains decomposable organic matter and exert oxygen demand on the receiving waters. Domestic sewage contains trace quantities of toxic metals also. Sewage treatment deposits sludge at the bottom while liquid waste consists of ions such as Ca^{2+}, Mg^{2+}, Na^+, K^+, Cl^-, NO_2^-, SO_4^{2-}, PO_4^{3-}, HCO_3^- etc.

5. Sediments.

The natural process of soil erosion gives rise to sediments in water. Sediments include **soil, sand and mineral particles** washed into aquatic environment by flood waters. In addition, large deposits of sewage sludge, pulverised coal ash and various industrial solids are disposed off into water. Suspended solid loadings reaching natural waters are about 700 times as large as solid loading from sewage discharge. Soil erosion gets enhanced 10 times as a result of agricultural development and about 100 times due to construction activities. Bottom sediments are subjected to anaerobic conditions and have the ability to exchange cation with surrounding aquatic medium. Sediments are important repositories for trace metals, *e.g.*, Cr, Cu, Co, Mn, Ni etc.

6. Synthetic Detergents.

Detergents include ingradients like **surfactants, builders, additives,** stabilizers and soil suspending carboxymethyl cellulose etc. The **surfactant** is a surface active agent. Alkyl Benzene Sulphonates (ABS) are considered as

surfactants. ABS showed remarkable resistance to biodegradation (hard detergents) and has been subsequently replaced by Linear Alkyl Sulphonate (LAS).

LAS undergo rapid biodegradation. **Builder** is usually a sodium polyphosphate of the type $Na_5P_3O_{10}$ or $Na_4P_2O_7$ acting as a sequestering agent. Both surfactants and builders cause serious pollution in water. **Additives** consist of anticorrosive sodium silicate, enzymes, perfumes and bleaching agents. Phosphates released into streams act as plant nutrient, thus supporting **eutrophic conditions.** Currently, **celluzyme** obtained from hermicola insolents, is added in detergents. The high percentage of sodium tripolyphosphate (STPP) in detergents may be partly replaced by enzymes.

7. Oxygen Demanding Wastes Causing Pollution.

Decrease in dissolved oxygen (DO) level is an index of pollution due to organic matter, *e.g.*, sewage, industrial wastes from food processing plants, run off from agricultural lands etc. All these materials undergo degradation by microbial activities in presence of DO. It causes deoxygenation process and quick depletion of DO.

Biological Oxygen Demand (BOD). **The degree of microbially mediated oxygen consumption in water is known as BOD.** BOD is a direct measure of biodegradable organic matter. Drinking water has a BOD of less than 1 mg/L. When BOD level reaches 5 mg/L, the water is said to be polluted.

8. Disease Causing Agents Creating Pollution in Water

Water has been a potential carrier of toxic, inorganic and organic materials, non-biodegradable matters and pathogenic microbes which can endanger health. The portable water contaminated with municipal sewage is the root cause of dangerous diseases in living organisms.

9. Radioactive Pollutants in Water

Radium is the most significant waste product and is considered to be a hazard in drinking water. Radioactive pollutants may reach the water bodies through numerous sources such as nuclear reactors, radioactive fall out, mining and processing of ores, leakage from underground nuclear detonations and research operations etc. Certain marine organisms have the capacity for accumulating radionuclides from water. **Phytoplankton** and fish may concentrate metal radionuclides by factors of 10^2 to 10^5. **Water supplies** must not contain 3 pico curies per litre of Ra-226, nor more than 10 pico curies per litre of Sr-90.

10. Plant Nutrients as Pollutant

Plant nutrients constitute an important limiting factor for plant growth. Nitrogen and phosphorus are the main nutrient species which enter fresh and marine systems changing **oligotrophic** water to intensely productive **eutrophic** conditions. According to **Wetzel** each phosphorus molecule promotes the incorporation of 7 molecules of nitrogen and 40 molecules of carbon in aquatic algae. These nutrients ultimately tend to accumulate in ground water.

Eutrophication

Eutrophication is a natural process, derived from the Greek word eutrophos meaning well nourished or enriched. This enrichment leads to other slow processes referred to as **natural aging of lakes.** *It is a phenomenon through which a nutrient rich bog in a shallow depression changes to leached bog deficient in nutrients.*

Sources of Nutrients. Eutrophication escalates rapidly, however when abnormally high amounts of nutrients from fertilizers, domestic and industrial

wastes, urban drainage, detergents, animal wastes and sediments enter water streams.

Types of Eutrophication. Eutrophication is mainly of two types :

(i) Natural Eutrophication. The process of lake aging characterised by nutrient enrichment is called natural eutrophication. During this process oligotrophic lake is converted into an eutrophic lake. It permits the production of phytoplankton, algal blooms and aquatic vegetation including water hyacinth, aquatic weeds, water fern and water lettuce which in turn provide ample food for herbivorous zooplankton and fish.

(ii) Cultural Eutrophication. This process is generally speeded up by human activities which are responsible for the addition of 80% nitrogen and 75% phosphorus to lakes and streams. Lake Mendota and Lake Washington have undergone rapid eutrophication due to man's activities. In India, recreational value of Kashmir lakes is reduced while Nainital lake is undergoing a rapid eutrophication as a result of sewage, domestic waste and detergent addition.

11. Thermal Pollutants in Water.

Chemical industries, electric power plants, atomic energy plants discharge their heated effluents into nearby lakes or rivers. **A coal-fired power plant at 40% efficiency** generates 16.7 joules of waste heat for every 41.8 joules of fuel burnt. A single 100 MW power plant may use one half million gallons of cooling water per minute. This process raises the temperature of water by 10°C to 15°C.

12. Pesticide Pollutants in Water.

Pesticides like insecticides, fungicides, herbicides, rodenticides and molluscicides enter in water through rain water, spray drift, run off from agricultural fields, domestic sewage, accidental spillage and industrial effluents etc. The annual world production of pesticides (organochlorines, organophosphates, carbamates, chlorophenoxy acids) grew from 6000 million pounds to 24000 million pounds. Pesticides hit the aquatic ecosystem and terrestrial organisms ranging from acute toxicity to invisible chronic effects in man, animals and plants.

13. Fertilizers as Pollutant.

Modern agricultural techniques have introduced NPK fertilizers into water systems. Nitrates and phosphates cause eutrophication and the whole stretch of water may become chocked. The less DO content may result in the death of aquatic biota.

14. Farm Waste in Water.

Increased number of cows, cattles, pigs and poultry farms cause considerable water pollution. Cow's dung is washed out which deposits on soil as slurry. This slurry may seep into drains and streams polluting them. A cow can produce as much organic waste as 20 persons and a pig as much as three people. These wastes contain several pathogens which are transmitted to man through water.

• DETRIMENTAL EFFECTS OF WATER POLLUTANTS

1. Effects of Inorganic Pollutants.

- Acidic pollutants are lethal to fish, most invertebrates and micro-organisms at pH below 4.0. Acid mine drainage is the major cause of fish kill.
- Strong alkalies like NaOH and KOH are known to produce asphyxiation by the coagulation of gill secretions in fish.

- Excess of inorganic pollutants like CO_3^{2-}, SO_4^{2-}, Ca^{2+}, Mg^{2+} make the water hard and unsuitable for boilers.
- Nitrate coming from nitrogenous organic matter causes blue baby syndrome or methaemoglobinemia in the range of 20 to 40 ppm.
- WHO pointed out that shell fish can concentrate mercury to the level of 10 mg per kg. Mercury poisoning caused **Minamata disease** in Japan in 1953 and killed several people.

2. Effects of Organic Pollutants.

- Organic compounds in water undergo degradation and putrefaction by bacterial activity. They consume dissolved oxygen which is an essential requirement of aquatic biota.
- Organic matter coming from domestic and agricultural lands contains nutrient which nourishes algal growth. There occurs a loss of all DO content resulting in dead pool of water.

3. Effects of Sewage and Domestic Wastes.

- Domestic sewage, which is primarily composed of spent water containing wine, faeces, soapy wastes, food materials and paper makes the water extremely anaesthetic.
- Accumulation of sewage and domestic wastes in water bodies retards the self regulatory capabilities of aquatic organisms.
- Sewage poses major threat to water courses. Today developed countries are fighting against thermal and chemical pollutants, while Indians have to combat with chemicals and pathogens with their limited resources.

4. Effects of Sediments.

- Sediments decrease fish population by blanketing fish nests, spawn and food supplies.
- Suspension may cause thickening of fish gills which may lead to asphyxiation of the fish.
- Sediments make the water cloudy and increases the cost of water treatment used for culinary purposes. Due to turbid water, the hunting ability of fish gets curtailed.

5. Effects of Synthetic Detergents.

- Detergent enzymes are potential allergens and can cause serious complications if inhaled or when they penetrate the body through wounds or cuts.
- Complex formation between NTA (nitrilotriacetate) and Hg or Cd increases the possibilities of transmission across the placental barrier into a foetus, thereby increasing the likelihood of birth defects.
- Phosphate, the major ingredient of most detergents, favour the luxuriant growth of algae which forms algal blooms. Such decomposing waters are known to produce toxins as strychnine which kills animals.
- The increased use of syndets, which replaced surface active agents like soap are able to produce foams even in very low concentrations, so aeration is not possible. As a result, the rate of re-aeration of a river water as well as the efficiency of sewage purification is reduced.

6. Effects of Pathogens.

- The enteric diseases are transmitted mainly by drinking contaminated water or swallowing food. The pathogens most frequently transmitted through water

cause infections of intestinal tract like typhoid, paratyphoid, amoebic dysentery, cholera, polio and infectious hepatitis.

- Intestinal helminthes, *i.e.*, Ascaris lumbricoides and Trichuristrichiura are also water borne. Entamoeba histolytica is the casual agent which causes internal amoebiasis and several extra-intestinal diseases.

7. Effects of Radioactive Pollutants in Water.

Living organisms are considered as the prey for radioactive contaminants in water. As compared to organic poisons, injurious effects of radionuclides are exceedingly high.

- In living organisms, radiation produces a whole host of extremely hazardous species like H^+, H_2, H_2O^-, H_2O^+, e^-, e^+, HO_2, H_3O^- and H_2O_2 etc., causing severe effects.
- The radioactive materials in water react with proteins of aquatic invertebrates and appear to deactivate enzymes by breaking S—H---S hydrogen bonds. With enzyme inhibition, cell growth may continue, but cell division may be stopped.
- Ionizing radiations in water mainly result in cellular damage. When a water molecule in the cell is irradiated, an electron is knocked out of orbit. This ejected electron can then attach to a normal water molecule making it unstable. It splits into H^+, OH^- and free radicals $H^\bullet$ and $OH^\bullet$. These free radicals react with various molecules in the cell which can no longer function normally and ultimately die.
- Traces of radioactive materials present in water cause cancers, leukemia, eye cataract, DNA breakage and carcinoma in man.
- Drinking water containing Rn-222, Ra-226 and Th-232 could accumulate dangerously in man causing somatic and genetic disorders.

8. Effects of Eutrophication.

- Eutrophication causes several physical, chemical and biological changes which considerably deteriorate the water quality.
- During eutrophication, algal bloom release toxic chemicals which kill fish, birds and other aquatic animals causing the water to sink.
- Decomposition of algal bloom leads to oxygen depletion in water. Thus with a high CO_2 level and poor oxygen supply, aquatic organisms begin to die and the clean water turns into a stinking drain.
- When O_2 level falls to zero (anaerobic zone), some bacteria drive oxygen through reduction of nitrates. On complete exhaustion of nitrate, oxygen as a last resort be obtained by reduction of sulphate yielding hydrogen sulphide causing foul smell and putrefied taste of water.
- Many pathogenic microbes, viruses, protozoa and bacteria etc. grow on sewage products under anaerobic conditions. It results into spread of fatal water-borne diseases such as polio, dysentery, diarrhoea, typhoid and viral hepatitis.
- In India, Dal, Nagin, Loktak lake and Hussain sagar are seriously chocked by aquatic weeds affecting fisheries production, utility for aquatic flora and aesthetic value.

9. Effects of Thermal Pollution on Aquatic Ecosystem.

- Refer to Thermal Pollution in the same Unit.

10. Harmful Effects of Industrial Pollutants.

- Industrial effluents cause deleterious effects on living organisms and may bring about death or sublethal pathology of kidneys, liver, lungs, brain and reproductive system.

- Disinfectants, which are added in water to control algal growth and bacteria may persist in water bodies and may cause mortality of fish, planktons and diatoms.
- It has been reported that free chlorine discharged by factories near **Mirzapur in UP** had caused heavy fish mortality in river **Sone** near Dehrion-son in **Bihar**.
- Mercury poisoning among people had resulted in crippling and often fatal diseases like **Minamata in Japan** (1953).
- Mines and smelters effluents containing cadmium had caused severe disease called **Itai-itai** in the people of Japan.
- Industrial effluents consisting of As, Pb and cyanide etc. cause cellular degeneration in brain which results in figidity, coma, stupor and numbness.

• CONTROL MEASURES OF WATER POLLUTION

We are now near the stage when water pollution has become a global problem partly because of population explosion and partly due to phenomenal advance in industrialisation. In India, 70% of the pollutant load of rivers, lakes and streams is from domestic waste. So obviously it is of no use to apply strict laws only to industries, if municipalities are given free reign to discharge their domestic wastes into water without any treatment.

Minimising Water Pollution.

Following methods can be adopted.

1. Stabilisation of the Ecosystem.

The principles involved in this technique include reduction of the waste at source, harvesting and removal of biomass, trapping of the nutrients, fish management and aeration.

2. Using Water Hyacinth to Remove Water Pollutants.

Water hyacinth is extremely efficient in absorbing and concentrating dissolved nutrients from water in which it lives. Introduction of this weed in the lagoon enhances even 1000 times purifying capacity of water. Experimental studies have shown that in a lagoon of 0.5 hectare having dense growth of hyacinth, with sewage retention time of 15 days, the daily wastes of 1000 people can be effectively treated. Water hyacinth is capable to absorb phenolic compounds commonly found in domestic and industrial sewage. The phenols so absorbed are broken down and can be utilized rapidly.

3. Chemical Methods.

Generally chemical precipitation, solvent extraction, electrodeposition, ion-exchange, ultra-filtration and activated carbon adsorption systems are applied to remove heavy metals. All these methods are extremely expensive.

4. Cooling Methods.

In some developed countries, thermal pollution abatement schemes are used to control water pollution. These methods include once-through cooling, cooling ponds, wet-cooling towers, evaporative towers and dry cooling towers.

5. Solar Power.

Solar energy is used for purifying the polluted waste water cheaply. Experiments concluded that a combination of sunlight and a catalyst such as titanium dioxide can dissociate chemical toxicants.

6. Removal of Phosphorus by Electrolysis.

In Norway, organic sewage is mixed with 10% of sea water and subjected to electrolysis to remove phosphorus from sewage water. Phosphorus compounds in sewage get precipitated as Ca or Mg phosphate. During electrolysis, these salts along with sludge and suspended particles adhere to magnesium hydroxide at the negative pole. H_2 gas liberated during electrolysis makes the phosphate and sludge to float on the surface as scum which can be scrapped off from the top layer. Chlorine gas produced at the positive pole can be used for disinfection of the outlet.

7. Removal of Salts by Reverse Osmosis to Purify Water.

Various salts can be removed by reverse osmosis by forcing the waste water through a semipermeable membrane under a pressure exceeding the osmotic pressure. During the process, flow occurs in the reverse direction. The solvent is attracted while the solute is repelled. The method is mostly applied to salinate the brackish water and to purify water from sewage.

8. Removal of Chlorophenols.

Chlorophenols, used as wood preservatives, pollute surface and ground water. Scientists at **Tampere University** of Technology, Finland used sand, vulcanite mineral, silica based material, called **celite** R-633 and pumice to clean up chlorophenol contaminated ground water. The method can remove 99.9% of chlorophenol from ground water at 5°C temperature.

9. Recycling, Renovation, Recharge and Reuse (4R Concept) of Waste Water.

In developed countries the waste water receives some sort of treatment before it gets mixed into water bodies. For example, urban sewage, sullage etc. may be recycled and reused to generate cheaper fuel, gas and electricity. **NEERI, Nagpur** has developed technology for reuse of waste water to provide cheap piped gas and generate electricity by recycling waste water. Recently, one distillery in **Gujarat** is effective in treating 450,000 litres of water daily and generating energy equivalent to that produced by 10 tonnes of coal.

• WASTE WATER TREATMENT

OBJECTIVE.

The objective of municipal and industrial waste water treatment is to extract pollutants, remove toxicants, neutralise coarse particles, kill pathogens so that quality of discharged water is improved to meet the permissible level of water to be discharged in water bodies or agricultural land. Treatment of water thus aims at reduction of BOD, COD, eutrophication etc. of receiving water bodies and prevention of bio-magnification of toxic substances in food chain. Various steps involved in treatment of waste water are as follows.

1. Preliminary Treatment.

Screening. In this treatment debris, gross solids, grit, oil and grease are removed by passing waste water through screens, grit chambers and skimming tanks.

2. Primary Treatment.

Primary treatment of sewage removes 60% suspended solids, 30% COD, 35% BOD, 10% P and 20% total nitrogen. It involves following processes.

(i) Sedimentation. About 50% suspended solids can be removed by gravitational settling under quiescent conditions.

(ii) Mechanical Flocculation and Coagulation. Fine suspended solids and colloidal particles are removed by passing waste water through clariflocculator and using coagulants like alum and polyelectrolytes.

(iii) Neutralisation. Highly acidic and alkaline waste waters are neutralised by lime slurry or NaOH and H_2SO_4 or CO_2 respectively.

3. Secondary (Biological) Treatment.

The dissolved and colloidal organic matter in waste water/sewage is removed by aerobic or anaerobic processes. The effluent from primary sedimentation tank is first subjected to **aerobic oxidation** in systems such as aerated lagoons, trickling filters, activated sludge units, oxidation ponds etc. Then the sludge obtained in these aerobic processes, together with that obtained in the primary sedimentation tank, is subjected to anaerobic digestion in the sludge digester (Fig. 2). Secondary treatment removes about 80% COD, 90% BOD, 30% P, 50% total N and oil, grease, phenol, grit, scum etc.

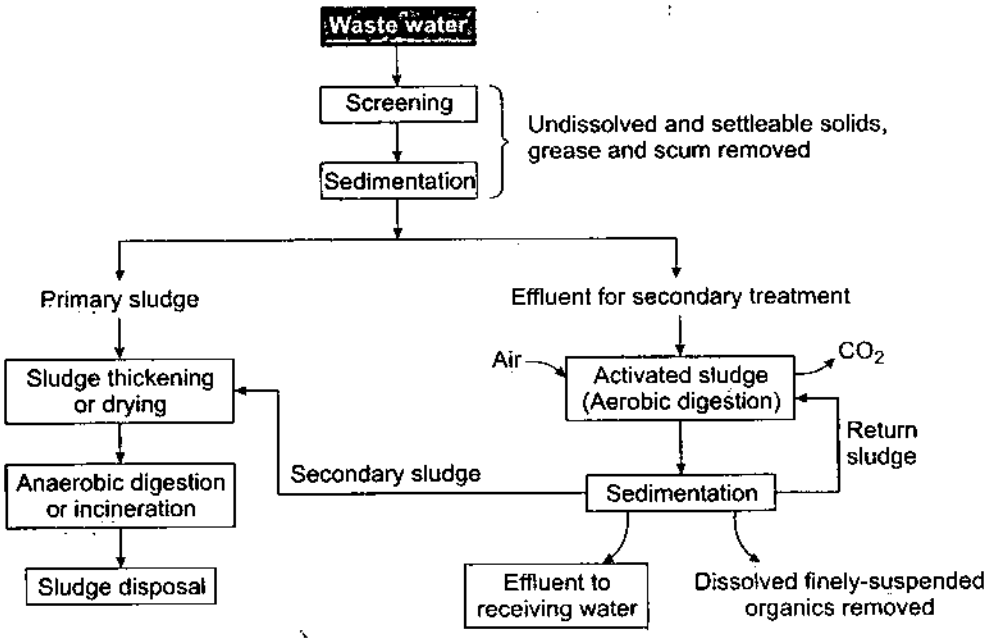


Fig. 2. Flow diagram of sewage/waste water treatment plant.

[For details—Refer to commonly used Secondary (Biological) Treatment processes for sewage and industrial waste water].

4. Tertiary Treatment.

Tertiary treatment is the final treatment meant for polishing the secondary effluents and removal of fine suspended solids, traces of organics and bacteria. The sewage effluent from secondary treatment plant is introduced into a **flocculation** tank where lime is added to eliminate calcium phosphate. The solution then enters to **NH_3 stripping** tower. Nitrogen present in waste water exists as NH_4^+ which is converted to gaseous ammonium ion at high pH(11). Phosphorus is removed by adding ferric chloride or aluminium sulphate. The remaining organic materials are removed by desalination, ion exchange and finally chlorination is used for disinfection.

The toxic, non-biodegradable chemicals in industrial waste water can be removed by adsorption (on activated charcoal), ion exchange, ultra-filtration, reverse osmosis and electrodialysis.

Commonly Used Secondary (Biological) Treatment Processes for Sewage and Industrial Waste Water.

(A) Aerobic Treatment Processes.

Aerobic treatment is a process of oxidation and decomposition of biodegradable organic part of sludge by micro-organisms in special tanks in presence of oxygen. Aerobic processes are listed below.

1. Trickling Filters. Conventional trickling filters consist of a bed of crushed stones or pebbles covered with biological slime. The waste water/sewage is sprinkled over the bed packing (Fig. 3.). As the liquid trickles over the packing, oxygen and the dissolved organic matter diffuse into the film to be metabolized by the micro-organisms in the slime layer. The degraded products such as CO_2, NO_3 etc. diffuse back out of the film and collected in the filter effluent.

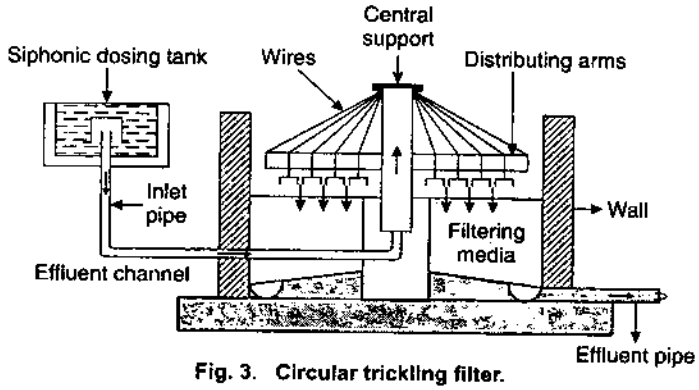


Fig. 3. Circular trickling filter.

Note. Although trickling filtration is an aerobic process, it is indeed a facultative system. Aerobic bacterial species are present in the upper layer of the filter while anaerobic species (Desulphovibrio) occur in the interfaces of rock media. Flavobacterium and Micrococcus etc. are also present in the filters.

Advantages.

- Trickling filter has greater resistance to toxic waste as compared to Activated sludge process and can recuperate more promptly from the overdose of toxicants.
- Lowers TSS and NH_3–N. BOD removal is 85%.

Disadvantages. Trickling filters are expensive. Their efficiency decreases with increasing load of waste water.

2. Activated Sludge Process (ASP). ASP is the most versatile continuous flow flocculated growth process involving an aeration stage, solid-liquid separation following aeration and a sludge recycle system.

The effluent from the primary clarifier enters to aeration tank. Aeration tank also receives bacterial flocs (active centres forming activated sludge) from the secondary settling tank. After aeration and agitation, the waste water goes to secondary settling tank. Here the micro-organisms utilise the oxygen and convert the organic matter into stabilized, low-energy compounds such as NO_3, SO_4, CO_2 and synthesize new bacterial cells. The settleable solids settle at the bottom of the tank. The sludge so produced is dewatered and disposed off in ocean or used in croplands and pastures etc.

Merits of Activated Sludge Process (ASP).

- Low retention time. BOD removal is upto 95%.
- ASP is used for the treatment of effluent from food processing, sugar, textile mills and antibiotic manufacturing industries.

Demerits of ASP.

- High cost of operation and maintenance.
- Huge sludge production and its disposal problem.
- Synthetic detergents such as alkyl benzene sulphonates (ABS) and polyethylene glycols are not susceptible to microbial degradation. They lead to foam formation and make the process difficult. Antifoaming compounds are used in such situations.

Recent modifications of conventional ASP include tapered or dispersed or extended aeration, contact stabilization, simplex process, aeration rotor process, lagooning and Swedish INKA process.

3. Autothermal Thermophilic Aerobic Digestion (ATAD). ATAD is a sludge digestion technology that is capable of achieving a high degree of stabilization and pathogen reduction. The thermophilic temperatures (40° to 70°C) are attained by using the heat released by the **exothermic microbial oxidation process.** About 15000 kJ of heat is generated per kilograms of volatile solids destroyed. In thermophilic digester, the volatile solids break down into CO_2, H_2O, NH_4HCO_3 and heat is released.

In an aerated environment, the thermophilic temperatures are attained without the addition of supplemental heat (other than the heat introduced by aeration and mixing) by conserving the heat released during biological oxidation.

Advantages of ATAD Technology.

- Volatile solid reduction is upto 50%.
- Destruction of all weed seeds make the biosolids highly suitable as a soil amendment or fertilizer.

Disadvantages of ATAD Technology.

- High capital and operating costs.
- Poor dewatering characteristics of digested biosolids.

(B) Anaerobic Treatment Processes.

1. Anaerobic Digestion Process. In this process about 95% of biodegradable waste is decomposed into biogas and the rest 5% into biomass. Three main steps are involved in the breakdown of organic waste under anaerobic conditions.

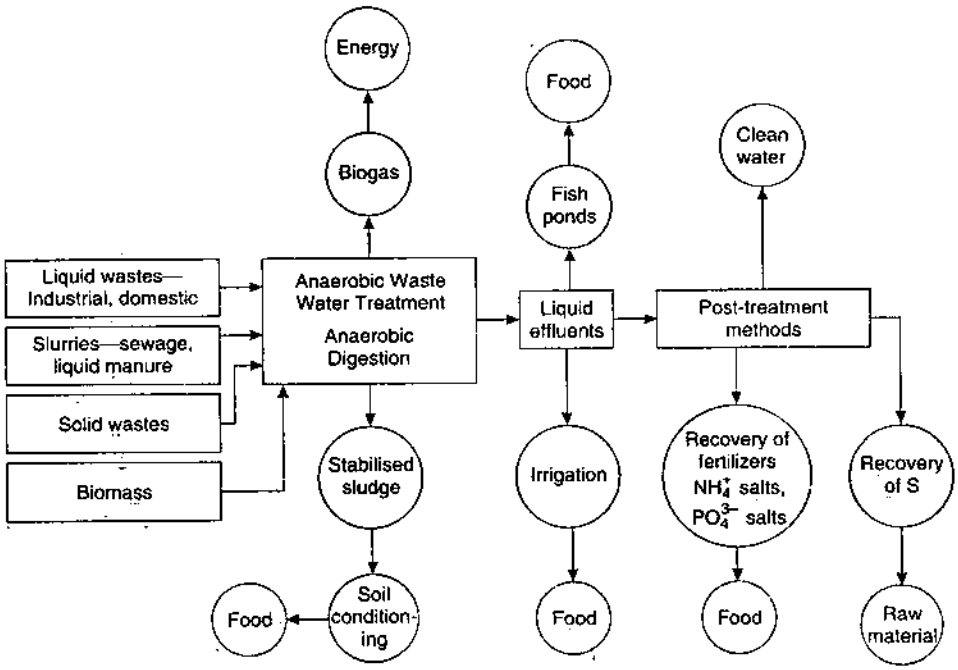


Fig. 4. Anaerobic waste treatment and recovery technology.

$$\text{Organic waste} \xrightarrow[\text{steps}]{\text{Hydrolytic}} \text{Organic acids, alcohol} \xrightarrow[35°C,\ pH\ 5-6]{\text{Acetogenic steps}} \text{Acetic acid, } H_2, CO_2$$

$$\xrightarrow[45°C,\ pH\ 6-8]{\text{Methanogenic steps}} CH_4, CO_2$$

These steps are hydrolysis of biopolymers to monomers, fermentation of monomers to volatile acids and methanogenesis (Fig. 4). Microbial species that act as tiny automatic chemical reactors in anaerobic degradation are : Actinomyces, Citrobacter, Escherichia and Micrococcus etc.

2. Upflow Anaerobic Sludge Bed (Blanket) Reactor (UASB) Process. UASB process is based on the settleability of microbial flocs to produce a region at the bottom of the digester where very high biomass concentration can be maintained. The effluent is fed in the bottom of UASB (Fig. 5) into the base of the sludge blanket. UASB process is simple, low-cost and best for waste water treatment with recovery and reuse.

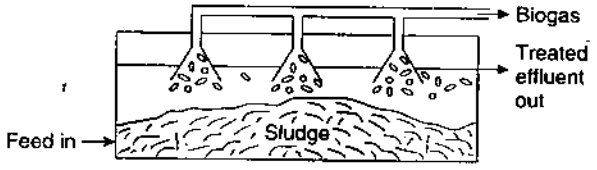


Fig. 5. Upflow anaerobic sludge blanket (UASB) reactor.

Anaerobic waste water treatment is preferred to other processes for the reasons.

- Energy (biomass) is produced instead of waste products.
- Cheaper than aerobic process in respect of treatment of medium and high strength waste waters (COD, 1500 mg L^{-1}).
- UASB can be considered as the core of a very promising environmental protection and resource recovery concept.

• PURIFICATION OF WATER FOR MUNICIPAL PURPOSES

The processes used in the treatment and purification of water are listed below :

1. Aeration. The raw water is first aerated by bubbling compressed air. This removes bad odours and CO_2 while Fe and Mn salts get precipitated as their hydroxides.

2. Sedimentation. The water is then allowed to stand in large settling tanks. Some of the heavier impurities present in water agglomerate and settle down by gravity.

3. Coagulation. The suspended impurities are removed by coagulation using alum, $FeCl_3$, lime or soda ash. The coagulant sodium aluminate removes HCO_3^-, Cl^-, SO_4^{2-} responsible for temporary and permanent hardness of water. By coagulation, turbidity is reduced to 20 ppm and bacterial load by 5%, thereby bringing about partial clarification of water.

4. Flocculation. The process of coagulation can be intensified by adding flocculants such as polyacrylamide, starch and activated silica.

5. Filtration. The partially clarified water is then filtered through sand gravity filter.

6. Disinfection. The elimination of offensive odour caused by dissolved organic substances in water are done by ozonization, chlorination, aeration, coagulation and ultra violet light treatment.

7. Ozonization. The water is treated with ozonised oxygen. Ozone sterilizes, bleaches, decolourises and deodorises water. Highly palatable water is sterilised with ozone but the cost involved is very high.

8. Chlorination. Chlorination is the best and cheapest method of sterilization of water. For chlorination, chlorine may be used directly in the liquid form or hypochlorates of calcium and sodium, *e.g.*, bleaching powder. It kills viruses and bacteria. The purified water is then supplied by municipalities through pipes for domestic purposes.

• SOIL POLLUTION

INTRODUCTION.

With rapidly advancing technology, man's impact upon the world of natural resources is beginning to prove overwhelming. Rapid urbanization, with the consequent increase in population and building construction, has resulted in the reduction of lands for the wastes to be disposed. Every year solid wastes are increasing tremendously all over the world. Several hazardous chemicals and the mountains of wastes are ultimately dumped on the lands. Dumping of industrial and municipal wastes causes toxic substances to be leached and seep into the soil and affects the ground water course (Table 3). Modern agricultural practices introduce numerous **pesticides,** resulting in severe biological and chemical contamination of soil. Indiscriminate deforestation, digging for minerals, destruction of grazing lands for human habitation have done irreparable damage to the land and even led to harsh climate changes. Some of the dangers posed to soil pollution are due to the fact that while number of earth's inhabitants are increasing, the earth's natural resources are by and large fixed as well as limited. However, the problem of **soil pollution differs from air and water pollution** in the respect that the pollutants remain in direct contact with the soil for relatively longer periods. Thus the soil is getting heavily polluted day by day by toxic materials and dangerous micro-organisms which enter the air, water and the food chain.

Table 3. Nature of pollutants in soil.

Source	Gases	Colloids	Suspended particles	Dissolved cations	Dissolved anions
Soil	CO_2	Clay Fe_2O_3 Al_2O_3 MnO_2	Clay sand silt	Na^+, K^+, Ca^{2+}, Mg^{2+}, Mn^{2+}, Co^{2+}, Fe^{3+}	CO_3^{2-}, HCO_3^-, OH^-, Cl^-, SO_4^{2-}, F^-
Decomposed organic matter	SO_2, H_2, NH_3, CH_4, CO_2	Organic waste materials	Humus, organic wastes	H^+, Na^+, NH_4^+	Organics, NO_3^-, SO_4^{2-}, Cl^-

Solid waste, often called the third pollution after air and water pollution, is that discarded material which arises from human activities. The annual solid waste production is : domestic and trade 8.5%, industries 15.2%, thermal power stations 7.3%, mining 67% and construction 2%.

• CAUSES OF SOIL POLLUTION

1. Industrial wastes
2. Urban wastes
3. Radioactive pollutants
4. Agricultural practices
5. Chemical and metallic pollutants
6. Biological agents

1. Industrial Wastes.

Industrial effluents are mainly discharged from pulp and paper mills, chemical industries, oil refineries, sugar factories, tanneries, textiles, steel, distillaries, fertilizers, pesticide industries, coal and mineral mining industries, metal processing industries, drugs, glass, cement, petroleum and engineering industries etc. It has been estimated that about 50% of the raw materials ultimately become waste products in industry and about 20% of these wastes are extremely deleterious polluting the soil.

2. Urban Wastes.

Urban wastes comprise both **commercial** and **domestic wastes** consisting of dried sludge of sewage. *All the urban solid wastes are commonly referred to as refuse.* This refuse contains garbage and rubbish materials like plastics, glasses, metallic cans, fibres, paper, rubbles, street sweepings, fuel residues, leaves, containers, abandoned vehicles and other discarded manufactured products contributing to soil pollution.

It is estimated that in **India** alone, about 450 million of urban population produces nearly 45 million tonnes of solid wastes causing chronic pollution of land and water. In critically polluted cities like Mumbai, Kolkata, Kanpur and Madras, about 8000 tonnes of waste material collects in a day. **Delhi, which is the third most polluted city,** collects about 9000 tonnes of garbage from its streets every day, to be thrown into its five land fills, thereby polluting the land areas.

Urban domestic wastes though disposed off separately from the industrial wastes, can still be dangerous. This is so because they can not be easily **degraded.** Over population and increasing consumption have totally changed the very complexion of domestic wastes into a complex mixture. The leachates that ooze out of the garbage heap, contain poisonous gases along with the partly decomposed organic material thereby causing soil pollution.

3. Radioactive Pollutants.

Radioactive substances resulting from explosions of nuclear devices, atmospheric fall out from nuclear dust and radioactive wastes penetrate the soil and accumulate there creating land pollution. Radionuclides of radium, thorium, uranium, isotopes of potassium (K-40) and carbon (C-14) are very common in soil, rock, water and air. Explosion of **hydrogen weapons** and cosmic radiations induce neutron-proton reactions by which nitrogen (N–15) produces C–14. This C^{14} participates in the carbon metabolism of plants which is then introduced into animals and man. **Radioactive wastes** contain several radionuclides such as strontium–90, iodine–129, cesium–137 and isotopes of iron which are most injurious.

Rain water carry Sr–90 and Cs–137 to be deposited on the soil, where they are held firmly with the soil particles by electrostatic forces. Soil erosion and heavy rains carry away the deposited Cs–137 and Sr–90 with the silt and clay. All these radionuclides deposited on the soil emit gamma radiations. Recently it has been indicated that some plants such as lichen and mushroom can accumulate Cs–137 and other radionuclides which concentrates in grazing animals [Also refer to Nuclear pollution in the same Unit].

4. Agricultural Practices.

Today with the advanced **agro-technology,** huge quantities of fertilizers, pesticides, herbicides, weedicides and soil conditioning agents are employed to increase the crop yield. Apart from these, farm wastes, manure slurry, debris, soil

erosion containing mostly inorganic chemicals are reported to cause soil pollution. USA alone produces about 18 million tonnes of agricultural wastes every year.

5. Chemical and Metallic Pollutants.

A number of industries including textiles, pesticides, paints, dyes, soap and synthetic detergents, drugs, cement, petroleum, paper and pulp, electroplating and metal industries pour their hazardous effluents in soil and water creating disastrous effects on living organisms. Today various **trace elements** such as Fe, Co, Ni, Cu, Zn, Ba, Pb, V, Mn, As, Hg, Mo and silicon are being added to the soil in one or the other form. Mn and Fe oxides have a tendency to concentrate trace metals by isomorphous replacement of ions. In many soils 50 to 100% of soil carbon is found complexed with clay containing organic and inorganic components which affect the soil texture, its fertility and stabilization of soil organic matter.

6. Biological Agents.

Soil gets large quantities of human, animals and birds excreta which constitute the major source of soil pollution by biological agents. The pathogenic organisms that pollute the soil may be classified into three categories as follows :

(i) Pathogenic organisms occurring naturally in contaminated soil such as bacteria, fungi, algae, protozoans.

(ii) Pathogenic organisms excreted by man.

(iii) Pathogenic organisms excreted by animals.

7. Soil Sediments as Pollutant.

Soil sediments refer to the depositions of trace metals such as Hg, As, Sb, Pb, Cd, Ni, Co, Mo, Cu and Cr. The process of sedimentation *is a comprehensive natural geomorphological process which operates through the chain of erosion of soils, transportation of sediments (eroded material) and deposition of these eroded materials in different paths of water bodies.* Sediments thus consist of soil and mineral particles washed from the land by storms and flood waters from crop lands and over grazed pastures.

Unscientific agricultural and forestry practices, uncontrolled dumping of terrestrial effluents, mismanagement of water sheds, ship mining and dredging, construction of dams, roads, reservoirs, overgrazing, infra structural projects and other practices contribute to sedimentation and soil pollution.

• DETRIMENTAL EFFECTS OF SOIL POLLUTANTS

Soil pollution is the result of industrial technological revolution and speedy exploitation of every bit of natural resources. Recently, a report published by **SOCLEEN** (Society for Clean Environment) on the ecology in Chembur area of Mumbai, India has revealed how recklessly man can exploit his land and environment. In Chembur, trees without leaves, buds and flowers are commonly seen due to **soil pollution.** Residents of the area have complained that they can neither grow flowers on the balconies nor vegetables in their gardens. The chief contributors to such a polluted atmosphere are FCI and Tata Thermal Plants which emit and add 1000 tonnes of toxic matters to the soil.

Effects of Industrial Pollutants.

- Industrial effluents when discharged through sewage system will poison the biological purification mechanism of sewage treatment causing several soil and water borne diseases. Most of these pathogens are insusceptible to degradation and are injurious to health.

- Some of the trade wastes contain pathogenic bacteria. For example, pathogen Anthrax bacilli is present in tannery wastes. Chemicals either emitted into air or applied by aerosol spray ultimately reach the soil where they have significant effect on plants and animals causing disruption in plant species.

Effects of Urban Waste Products.

- Urban wastes cause offensive odour and clogging of ground water filters. Suspended matter in sewage can blanket the soil, thereby interfering with the soil moisture.

Effects of Radioactive Pollutants.

The problem of radioactive wastes dumped into the soil is more complicated. This is so because every radioactive element like radium, uranium, thorium and plutonium etc. can remain active in soil for thousands of years. Since the radioactive wastes are produced in tremendous quantities and have a high activation energy, they create an extremely difficult public health problem.

- The aquatic flora and fauna used as food by man could accumulate dangerous amounts of radio-isotopes causing disruption of metabolic changes and physiological disorders.
- Radioactive pollutants can produce great human misery. When food containing radionuclides is taken by man, some of them concentrate in specific body organs where they cause a number of undesirable diseases of digestive tract. Even the thyroid gland is damaged due to accumulation of iodine. Cs-137 is taken by body in place of potassium.

Effects of Pesticides.

Modern agriculture rely heavily on **pesticides**. Although these chemicals enhance vegetation but they disrupt the natural ecosystem.

- Pesticides not only pose a potential hazard to man, animal, fish and livestock but they severely affect the desired yield of crop and soil. Even the accepted dose of pesticides create deleterious effects on soil fertility. According to a report **Death in the Grab of Pesticides,** pesticides spread most alarmingly in the environment through migration. They are washed off from the crops into the water, enter water bodies, penetrate with fodder, animals and hence food stuffs. In **India,** 35000 to 40000 tonnes of hazardous chemicals are sprayed on the agricultural crops each year.
- Pesticides retained in soil concentrates in crops, vegetables, cereals and fruits which taint them to such an extent that they are not useable.
- Various vegetables, fruits, rice, grain, wheat, gram, barley and maize are known to contain significant amount of .DDT, BHC and other organochlorine pesticides. They persist in the soil producing long term effects on vegetative cover. **Poly chlorinated biphenyls (PCBs)** accumulate in the soil and plants which ultimately enter into human bodies.
- Persons who used vegetables contaminated with 0.5 g or more PCBs developed darkened skin, eye damage and severe acne. DDT accumulates in the food chain. It is continuously recycled in living systems.
- Pesticides like DDT, endrin, dieldrin, heptachlor etc. are known to seep gradually through soil into ground water and eventually contaminate public drinking water supplies.
- Herbicides and chlorinated pesticides are very potent pollutants of the soil and affect soil texture and function of the ecosystem. Many of these have longer lasting effects and if used indiscriminately may be suicidal for

people. Even certain herbicides, such as dioxan is found to cause congenital birth defects in offspring of experimental female. Their excessive use has also resulted in defoliation of forests adversely affecting flora and fauna.

- Organophosphate pesticides cause extreme muscular weakness, tremors and dizziness in poisoned animals.
- Many hunting birds feeding on grains, particularly contaminated with high levels of DDT, are threatened with extinction.
- People in contact with pesticides, such as, farmers, farm workers and agriculturists are much more prone to be poisoned by them. Their excess absorption leads to greater accumulation of acetylcholine in the body. Chronic absorption damages liver, kidney causing malfunctioning, excess of amino acid in urine and blood abnormalities.
- Pesticides cause several disastrous effects. In **India on December 3, 1984** in a tragic accident at **Bhopal,** about 3,000 to 4,000 people died and thousands suffer chronically from serious diseases of eye, skin, lung, brain etc. due to methyl isocyanate (MIC) leakage being manufactured by Union Carbide. Today children born have to start their life with a body burden of pesticides which increases with age.

Effects of Biological Agents.

Soil inhabit distinctive flora and fauna, such as, bacteria, algae, fungi, protozoa, rotifers, nematodes, earth worms, actinomycetes and several pests which make the biological system of soil complex. Some organisms also help in maintenance of soil fertility while majority of the micro-organisms act as chronic pollutants. Soil has been a potential carrier of microbial growth, non-biodegradable matters and pathogens which can endanger human health and life.

- Pathogenic soil bacteria are chronic disease carrier which are transmitted from man to soil or vice versa causing cholera, typhoid, bacillary dysentery, paratyphoid fever etc.
- The eggs of parasitic worms helminthes get incubated in the soil, these eggs and larvae are highly infective.
- Geohelminthes are reported to suck vitamins and proteins from the intestinal nutrients of the host. Such absorption of essential nutritional constituents results in severe malnutrition.
- Fungi and actinomycetes—the saprophytes normally develop in soil or vegetation. They cause most serious subcutaneous and systemic mycoses.
- Some bacteria and fungi in soil secrete growth hormones that affect root growth. Antibiosis microbes in soil produce antagonistic effect through metabolic products which may inhibit the growth of symbiotic bacteria.

Effects of Soil Sediments.

- Suspended sediment is usually eroded top soil and is the most fertile portion of the soil. Eroded soil is deteriorated and the carried top soil could deposit in places where fertility is a liability.
- Water reservoirs can be filled by sediments and decrease their storage capacity. **Tarbela Dam Reservoir in Pak,** world's largest, has a silt load of about 16 times larger than predicted by dam's engineers.
- In **India, Kosi canal** has been so heavily silted in its 20 years existence (because of overgrazing its watershed) that it now provides water to only few irrigation areas. It has reduced from 570,000 hectares to 81,000 hectares.
- Sediments adversely affect the physical and chemical compositions of water. It carries numerous ions (*e.g.*, Na^+, K^+, NO_3^-, Cl^-, SO_4^{2-} and PO_4^{3-}) from the agricultural fields contaminated with pesticides.

- Sediment causes eutrophication in the whole stretch of water bodies affecting severely aquatic life. It makes water unfit for municipal water supplies and for industrial purposes.
- Excessive suspended load of clay and silt in the river water damages turbines which are used to generate hydroelectricity.

• CONTROL MEASURES OF SOIL POLLUTION

With the rapid pace of industrialization and increasing population density, numerous pollutants have posed a serious threat on living organisms. Extensive solid wastes and the use of biocides etc. have put the interest of agriculture and aqua-culture at cross purposes.

The various approaches to control the soil pollution are as follows :

1. Production of Natural Fertilizers. Organic wastes contained in animal's dung can be used for preparing **compost manure** and biogas rather than throwing them wastefully polluting the soil. The use of bio-pesticides should be encouraged in place of toxic pesticides.

2. Ban on Toxic Chemicals. Ban should be imposed on chemicals, biocides, highly resistant pesticides which are fatal to plants and animals.

3. Using biodegradable organic wastes for the generation of biogas. Night soil (human faeces) and cattle dung can be used in the biogas plant to produce inflammable methane gas.

4. Microbial degradation of biodegradable substances is one of the scientific approaches for reducing soil pollution.

5. Recycling of trees can also prevent soil pollution.

Other Control Measures are :

1. Launching extensive afforestation, community forestry programmes and implementing deterrent measures against deforestation.

2. Conservation of soil to prevent the loss of precious top soil from erosion and to maintain it in a fertile state for agricultural purposes.

3. Sponsoring more intensive R and D efforts on bio-fertilizers, utilization of wastes by recovery, reusing and recycling solid wastes, safer treatment and disposal of hazardous wastes.

4. Security land fills have to be constructed for permanent disposal of hazardous and recalcitrant industrial wastes.

5. Transforming intensive agriculture into a sustainable system by measures such as

(i) Maintaining a healthy soil community in order to regenerate soil fertility by providing organic manures, increasing fallow periods, avoiding excessive use of chemical fertilizers.

(ii) Infusing biodiversity in agriculture by sowing mixed crops and crop rotation.

6. Effective treatment of domestic sewage by suitable biological and chemical methods and adopting modern techniques of sludge disposal.

7. Municipal wastes have to be properly collected by segregation, treated and disposed scientifically. Recycling of glass, paper, plastics should be done carefully.

8. Industrial wastes have to be properly treated at source, by segregation of wastes or adopting integrated waste treatment methods. **Basic slag**, the major byproduct of steel industries, can be used for making **nitrophosphatic fertilizer**.

9. Enforcing **environment audit** for industries and promoting **eco labelled products.**

10. Implementing stringent and pro-active population control programmes.

11. Formulation of stringent pollution control legislation and effective implementation with powerful administrative machinery.

12. Imparting informal and formal public awareness programmes to educate people at large regarding health hazards and undesirable effects due to environmental pollution. Mass media, educational institutions and voluntary agencies should be involved to achieve these objectives.

13. Extending market support for recoverable products through fiscal concessions.

• MARINE POLLUTION

Marine pollution *is defined as the discharge of waste substances into the sea resulting in harm to living resources, hazards to human health, hindrance to fishery and impairment to quality for use of sea water.* Marine pollution is associated with the changes in physical, chemical and biological conditions of the sea water. This water is also unfit for human consumption and industrial purposes because of high salt content. Chemically it is a solution of 0.5 m NaCl and 0.005 m $MgSO_4$ containing traces of all conceivable matter in the universe. Like the land, the air, the rivers, the lakes, our seas and oceans also suffer from pollution.

• CAUSES OF MARINE POLLUTION

- **Rivers** carrying the pollutants from their drainage basins finally pour them into the sea contributing to marine pollution. These include sewage sludge, synthetic detergents, agrochemicals, metals, waste heat from thermal and nuclear power plants.
- Tankers transporting oil add significantly to oil pollution. Earlier ballast water containing residual oil from tankers was released into the sea. Now the oil floating on ballast water is removed by newly designed **load-on-top-tankers** before ballast water is let-off.
- **Oily wastes** from petroleum, refinery, lubricating oil using industries, automotive wastes, accidental damages to offshore, disposal of drilling muds, shipping operations at the coastal belt, ship accidents add to extensive marine pollution.
- **Oil spills** mixed with sullage, silt, plastics, pesticides and insiduous toxic compounds are pervasive and complex the pollution problems in sea.
- An important source of marine pollution is the leakage of toxic substances, radionuclides etc. from large containers which are dumped in deep sea considering sea to be a better disposal site than land.

• EFFECTS OF MARINE POLLUTION

Oil pollution in water has been an inevitable consequence of the dependence of rapidly growing population on oil based technology. World's ocean system has been subjected to 1951 cases of oil spills between 1975 and 2010. A total of 5432000 tonnes of oil has been split into the ocean. The detrimental effects of oil in sea water are as follows :

1. Effects on Marine Ecosystem.

- Extensive spreading of oil in sea water affects the floating plantation severely. In areas of oil exploration, fishing gear and craft operations get critically affected by crude oil and lumps of oily tar.

- Waste from oil refineries and discharged petroleum from ships cause heavy damage to fishery. Recently, heaps of dead fish were washed ashore between **Dabolim and Velcao coast in Goa.**
- Direct oil coating unable the fishes to respire and clog their gill slits. Soluble aromatics present in oil acutely affect the aquatic organisms by disrupting their biological, physiological and behavioural activities.
- Sub-lethal dose, *i.e.*, 1 to 100 ppb of oil component disturbs chemical sensing and communication system of marine organisms.
- Hydrocarbons in oil get incorporated in body tissues of marine animals. They cause **anaesthesia and necrosis** in a wide variety of lower animals. Studies conducted on oil spills close to sea shore revealed the immediate massive destruction of marine life like fish, worms, crabs, invertebrates and lobsters etc.
- Oil pollutants may block the taste receptors of organisms and may mimic the natural stimulation which gives rise to false responses to organisms.
- Emulsified oil may reach the bottom of sea damaging aquatic animals and plants. Oil may serve as a concentration medium for fat soluble poisons like pesticides. These poisons may seriously accumulate in aquatic biota posing deleterious effects.

2. Effects on Man.

Oil in marine water also affects man critically in the following ways :

- Liquid paraffins can remove oil from exposed skin causing dermatitis, leukopenia and pneumonia in lung tissues.
- Crude oil contains sulphur compounds, small amount of nitrogen, little olefin, metals like iron, nickel and vanadium. These are extremely lethal. Carbonyl sulphide is dangerously poisonous. Actually it dissociates to hydrogen sulphide which acts on central nervous system resulting in death mainly from respiratory paralysis.

3. Effects on Birds.

Ironically the oil that drives millions of vehicles around the world, sometimes drives countless birds and animals to a most **cruel death.**

- Birds are specially vulnerable to damage from oil coating. The spilled oil break down their natural insulating oils and waxes which shield the birds from water. Ultimately they lose insulation, start shivering and may freeze to death in winter. About 25,000 birds died in **Torry Canyon incident.**
- Oil spilling in sea water causes abnormally low body temperature in birds resulting in **hypothermia.** Nearly 150 rare species of bald eagles also became victims, when they ingested oil during **Exxon Valdez accident,** scavenging oily sea birds carcasses.
- About 100 sea otters died when their fur became saturated with oil by losing insulation. Several birds suffered from respiratory ailments, liver and kidney damage caused by ingesting oil while cleaning their coats.

• CONTROL MEASURES OF MARINE POLLUTION

Several methods have been devised to deal with oil floating on the sea.

1. Dispersion. Dispersion of oil is most satisfactory method for removing oil from the sea surface. A dispersant contains a surfactant, a solvent and a stabilizer which cause the oil to spread farther and disperse. The solvent enables the surface active agents to mix with it and penetrate into the oil slick forming emulsions. The stabilizer fixes the emulsion and prevents it from coalescing once it is formed. Dispersion increases the slick surface area increasing microbial decomposition.

Although dispersants are effective in diffusing a oil slick, these chemicals are toxic to aquatic biota.

2. Evaporation. Evaporation removes about 50% of oil during an oil slick's life time. Low boiling hydrocarbons such as benzene, toluene and xylene are lost rapidly from the water surface. Much of the oil that evaporates is photo-oxidized in air while some of it may return to the seas as atmospheric fall out. **Photolysis and physico-chemical changes** in oil cause it to coalesce forming tar balls which would sink in water decreasing its toxicity.

3. Emulsification. It is an effective weathering process in which water is incorporated into the floating oil forming a water-in-oil emulsion. Since emulsified oil droplets sink in water body, oil stays in water with its toxic components like benzene, toluene or xylene entering the food chain with disastrous long term effects.

4. Absorbents. An oil spill can be cleaned up by using absorbents such as peat, moss, saw dust, straw and pine bark etc. Synthetic absorbents include polystyrene, polyethylene, polypropylene and polyurethane which are quite promising. On applying to the oil slick, they absorb the oil and prevent it from spreading. When the absorbent material is removed from the water, the oil also gets removed.

5. Using chemical additives. Chemical additives can be used to solidify oil from water surface. Mechanical methods involving the use of additives and skimmers have been satisfactorily used to remove oil slicks.

6. Floating booms. Now floating booms are in common use in harbours and areas where transfer of petroleum products occur.

7. Improved navigation aids. Hazard warning instrumentation and offshore drilling operations can effectively protect the water from oil pollution. Development of submerged pyramid shaped canopies to cover the drill hole area, use of mechanical or pneumatic (air curtain) walls around the drill site and physical **encapsulation of drill** and its hole can be suggested to escape from the pollution hazards of sea water.

8. Using micro-organisms in oil clean up. Microbes can be deployed as voracious scavengers removing all kinds of oil pollutants. Various varieties of Pseudomonas can consume esteric compounds and hydrocarbons from the oil. **The gene secreting enzymes are found on plasmids, small and semi-autonomous rings of DNA.** Some microbes can ingest dispersed oil droplets and subsequently deposit them as faecal pellets.

Other Control Measures.

- Toxic effluents from industries and sewage treatment plants should not be discharged in coastal waters.
- Dumping of toxic, hazardous wastes, sewage sludge and oil ballast should be banned.
- Oil and grease from service stations should be processed for reuse.
- Developmental activities on coastal areas should be minimized.

• NOISE POLLUTION

Noise is a normal phenomenon of life and is deemed to be one of the most effective alarm system in man's physical environment. The word **noise** is derived from the Latin word **nausea,** *meaning a feeling of sickness at the stomach with an urge to vomit.* **Noise** is defined in a number of ways.

- Noise is unwanted, unpleasent or disagreeable sound that causes discomfort.
- Noise is the wrong sound, in the wrong place at the wrong time.

A particular sound may be musical to one but noise to another, pleasent when soft but noise when loud, random or prolonged. So the question is why the sound which at one place or time gives soothing touch to the ear becomes noise and irritating on another occasion.

Noise pollution may also be defined in several ways.

- *Any unwanted electromagnetic signal that produces a jarring or displeasing effect and which interferes with human communication, comfort and health.*
- *Noise pollution is the unwanted sound dumped into the environment without regard to the adverse effect it may have.*
- *Hell created by Bel (undesirable sound) is referred to as* ***noise pollution.***
- *Noise pollution like smog is a slow agent of death.*

• CAUSES OF NOISE POLLUTION

Noise is either **natural** such as thunder or **man made.** The main sources of man made noise in urban areas are mechanised automobiles such as trucks, buses, motors, scooters, fire engines, police cars, ambulances etc., factories, industries, trains, aeroplanes and accessory noise producers such as horns, sirens, loud speakers, musical instruments, TV, radio, transistors, shouting, barking of dog etc. Man made noise also includes social gatherings, marriage and birthday functions etc. Noise sources may be classified into following categories.

1. Occupational or Industrial Noise.

High intensity sound or **noise pollution** is caused by many machines of numerous factories, industries and mills. Industrial noise, particularly from mechanical saws of pneumatic drill is unbearable and is a nuisance to public. For example, in the steel industry, the workers near the heavy industrial blowers are exposed to 112 dB for eight hours and suffer from the occupational pollution.

Table 4. Standard for noise levels (dB).

Industrial source	Noise level	Industrial source	Noise level	Industrial source	Noise level
Steel plate riveting	130	Newspaper press	101	Textile loom	112
Boiler maker shop	120	High speed drill	85	Farm tractor	103
Circular saw	110	Oxygen torch	126	Milling machine	90

2. Transport Noise.

It mainly includes road traffic noise, rail traffic noise and air craft noise. The number of road vehicles like motors, scooters, cars, buses, trucks and particularly the diesel engine vehicles have increased enormously.

People live in an environment of noise generated by blasting horns, rumbling tyres and screeching brakes. Awful road conditions mainly contribute to the misry. Road traffic noise varies depending on a number of operating factors of vehicles, traffic density and the hour of day. Heavy diesel engined trucks are the noisiest vehicles on the roads.

Traffic noise is accurately measured in dB and noise levels given on the L_{10} (18 hour) index. The limits for diesel or petrol engined cars are 70 dBin UK, 83 dBin France, 70 dBin Switzerland and 80 dBin India. The Central Pollution Board, India has prescribed permissible sound levels for cities and divided them into four zones.

Areas	Sound level, dB	Areas	Sound level, dB
Industrial	75	Commercial	65
Residential	50	Sensitive areas	45

3. Neighbourhood Noise.

This type of noise includes disturbance from house hold gadgets and community. Common noise makers are musical instruments, TV, VCR, radio, transistors, telephones, washing machines, vacuum cleaners, fans, mixers, coolers, air conditioners etc. Even since the industrial revolution noise in environment has been doubling every ten years.

4. Indoor Noise and Outdoor Noise.

Indoor noise is created in the adjacent room or in the same room where noise is noticed. Examples of indoor noise are crying of babies, banging of doors, movement of furniture, conversation of the occupants etc. **The outdoor noise** is created from nearby streets. The largest source of outdoor noise is automobile traffic.

• EFFECTS OF NOISE POLLUTION

Physiological and Psychological Effects of Noise.

- **Noise pollution** affects human health, comfort and efficiency. It causes contraction of blood vessels and makes the skin pale.
- It causes muscles to contract leading to nervous breakdown, tension and even insanity.
- **Noise** effects are anxiety, stress reactions and fright. These adverse reactions are coupled with a change in hormone content of blood, which in turn produces increased rate of heart beat, constriction of blood vessels, digestive spasms and dilation of pupil of eye.
- It may cause damage to heart, brain, kidney, liver and may also produce emotional disturbances.
- **Loud sounds** can cause an increased secretion of hormones of pituitory gland, *i.e.*, Adreno Cortico Tropic Hormone (ACTH). **ACTH** in turn stimulates the adrenal gland. Through a variety of influences, these hormones trigger various effects, such as, enhancement of sensitivity of the body to adrenalin, increase of blood sugar levels, suppression of immune system and decreasing the efficiency of liver to detoxify blood.
- Auditory fatigue appears in the 90 dB associated with whistling and buzzing in ears. Temporary deafness occurs at 4000–6000 Hz, and this effect is known as **Temporary Threshold Shift (TTS)**. Permanent loss of hearing occurs at 100 dB due to continuous noise exposure. Under such conditions, the auditory threshold shift is called **Permanent Threshold Shift (PTS)**.
- Besides chronic hearing loss, there may be instantaneous damage or **accoustic trauma** which may be caused by very high intensity impulsive noise resulting from an explosion or sudden excessive noise of more than 150 dB.
- Impulsive noise also cause **psychological** and **pathological disorders.**
- Physiological disorders are also developed due to imbalance in functioning of body systems and due to continuous exposure to noise. These are neurosis, insomnia, hypertension, hepatic diseases. giddiness, peptic ulcers, undesirable change in gastro intestinal activities, behavioural and emotional stress.
- Noise and physical vibrations from hand held tools may cause severe effects often described as **white fingers,** dead hands or **Reynaud's phenomenon** or **pneumatic drill disease.** Pain, cyanosis (blue colouration) and numbness of finger results from moderate vibrations while damage to bones and joints in the hands with swelling and stiffness can be caused by severely high vibrations.

- **Ultrasonic sound** can affect the digestive, respiratory, cardio vascular systems and semicircular canals of the internal ear.
- **Brain** is also adversely affected by loud and sudden noise, such as, that of jet and aeroplane noise etc. People are subjected to **psychiatric illness.** It is also injurious to the health of pregnant woman and foetus.
- It has been reported that **blood** is also thickened by excessive noises. Changes in breathing amplitude have also been reported due to impulsive noise.
- Noise causes eosinophilia, hyperglycaemia, hypokalaemia and hypoglycaemia by a change in blood and other body fluids.
- The high intensity pulse of sound has its worst effect on the nervous system and also affects psychomotor performance.
- Our **optical system** is also a prey for noise pollution. Pupillary dilation, impairment of night vision and decrease in the rate of colour perception are some of its severe effects.
- Noise is responsible for disturbing the whole **biological system.** The internal wreckage caused by shriek of siren or the roar of a jet engine includes gastric ulcers and thymus gland atrophy.
- **Sonic boom** produces shock waves moving faster than the speed of sound. **Sonic boom is the worst killer of peace than noise.** Experiencing it is like living inside a drum beaten by an idiot at insane intervals.
- Even the non-living things such as buildings undergo physical damage by cracks, broken windows, doors and glasses etc. by sudden and explosive sounds.

• CONTROL MEASURES OF NOISE POLLUTION

The following approaches are available for noise control :

1. **Modifying some of the present practices** and procedures in order to minimise the noise. For example, reducing automobile traffic, outlaying sirens, discouraging stereos without headsets, using glue instead of rivets, etc.

2. **Shielding the sources of noise generation.** For example, use of sound-absorbing motor mountings, better installation, better design, use of motor enclosures, vibration damping or absorbing materials in automobiles and dishwashers, etc.

3. **Shielding the noise receiver**, *i.e.*, using earplug, ear muffs, helmets, control booths, etc.

4. **Shifting noisy sources** and things away from people, for example, isolating airports, industrial complexes, etc.

5. **Using acoustic enclosures**, mufflers and sound absorbing silencers. Noise in industrial establishments can be controlled by using acoustic screens, flexible couplings, hoses, quieter valves, unidirection fan and by effective implementation of administrative and engineering controls.

• THERMAL POLLUTION

INTRODUCTION.

The term thermal pollution has been used to indicate the detrimental effects of heated effluents discharged by thermal, coal fired, atomic and nuclear power plants. It denotes the impairment of quality and deterioration of aquatic and terrestrial environment.

Thermal pollution may be defined in the following ways.

- *The warming up of an aquatic ecosystem to the point where desirable organisms are adversely affected.*
- *Addition of excess of undesirable heat to water that makes it harmful to man, animal or aquatic life, or otherwise causes significant departures from the normal activities of aquatic communities in water.*
- *Heated effluents, either from natural or man made sources, contaminated with water supplies, may be harmful to life because of their toxicity, reduction in normal oxygen level of water, aesthetically unsuitable and spread diseases [WHO].*
- *Thermal pollution is a by-product of rapid and unplanned industrial progress and over population.*

• CAUSES OF THERMAL POLLUTION

1. Nuclear Power Plants.

Nuclear power plant toxicants, including drainage from hospitals, research institutes and traces of toxic radionuclides discharge unutilized heat into nearby water streams. The operation of power reactors and nuclear fuel processing units constitute the major contributor of heat in the aquatic environment. In addition, accidental leakage of radiation from nuclear reactors in water raise the temperature of surrounding aquatic system. Heated effluents from power plants are discharged at 15°C higher temperature than the coolant receiving waters thereby causing thermal pollution.

2. Coal-fired Power Plants.

Some thermal power plants utilize coal as fuel, while a few plants use nuclear fuel. The condenser coils of coal-fired power plants are cooled with water from nearby lake or river and discharge the hot water back to the stream increasing the temperature of water to about 15°C.

3. Industrial Effluents.

Heat producing industries, *i.e.*, steam-electric power industry, thermal or nuclear power plants, refineries, steel mills etc. are the major contributor of thermal pollution. These industries utilize only 1/3 of the energy provided by fossil fuels for their operations. Remaining 2/3 is lost in the form of heat to the nearby water body used for cooling, thereby raising its temperature upto 15°C. In modern stations, producing 100 MW power, nearly one million gallons of water is discharged in an hour with increase in temperature of the cooling water by 10°C.

4. Domestic Sewage.

Domestic sewage is commonly discharged into rivers, lakes, canals or streams with or without waste treatment. The municipal sewage normally has a higher temperature than the receiving water. The organic and the other oxidisable matter present in the sewage raises the temperature of water bodies.

5. Hydroelectric Power.

Generation of hydroelectric power, sometimes, results in negative thermal loading causing thermal pollution.

• EFFECTS OF THERMAL POLLUTION

1. Reduction in Dissolved Oxygen. Concentration of dissolved oxygen decreases with increase in temperature of water. For example, **DO** concentration is 14.6 ppm in water at a temperature of 32°F and 6.6 ppm at 64°F. Thus the cold water fish which requires about 6 ppm to survive could not tolerate the high water

temperatures. High temperature becomes a barrier for oxygen penetration into deep cold waters. Thus the organisms would die because of oxygen starvation.

2. Change in Water Properties. A rise in temperature changes the physical and chemical properties of water. The vapour pressure increases sharply, while the viscosity of water decreases. The decrease in density, viscosity and solubility of gases increases the settling speed of suspended particles which seriously affect the food supplies of aquatic organisms.

3. Increase in Toxicity. The rising temperature increases the toxicity of chemicals, pesticides and detergents in the effluent. A 10°C rise in temperature doubles the toxic effect of potassium cyanide, while a 80°C rise in temperature triples the toxic effect of *o*-xylene causing massive mortality of fish.

4. Interference with Biological Activities. Temperature is considered to be of vital significance to physiology, metabolism and biochemical processes in controlling respiratory rates, digestion, excretion and overall development of aquatic organisms. The temperature changes alter these reactions and totally disrupt the entire ecosystem.

5. Interference with Reproduction. In fishes, several activities like nest building, spawning, hatching, migration and reproduction etc. depend on some optimum temperature. For instance, the maximum temperature at which **lake trout** will spawn successfully is 8.9°C. The warm water not only disturbs spawning but also destroys the laid eggs.

6. Variations in Reproductive Rates. The increase in temperature triggers deposition of eggs by female. The triggering is particularly dramatic in estuaries shall fish, oysters and clams which spawn within four hours of the water temperature reaching the critical level. The **Atlantic salmon eggs** hatch in 14 days in winter (2°C) and in 90 days at 7°C. Harring eggs hatch in 47 days at 0°C and in 8 days at 14.6°C. These are the critical temperatures for reproduction. It has been reported that Gammarus above 7.8°C produces only female offsprings.

7. Change in Metabolic Rate. Fishes show a marked rise in basal rate of metabolism with temperature to the lethal point. The respiratory rate, oxygen demand, food uptake and swimming speed in fishes increase. In brown trout, the rate of oxygen consumption rises steadily till lethal temperature (28°C) is reached. Sockeye salmon cruises swims twice as fast in water at 15°C as at 0°C, but above 15°C its speed declines.

8. Increased Vulnerability to Disease. Activities of several pathogenic micro-organisms are accelerated by higher temperature. Hot water causes bacterial disease in salmon fish. Banded sun fish fails to develop eggs above critical temperature. In carp, the cell division is prevented at the temperature range of 20 to 23°C. Several pathogens become more virulent and the fish less resistant. As a consequence, pathogens vigorously attack aquatic animals. The bacteria Chondroccus is believed to be responsible for the massive kill of blue black salmon in the Columbia river.

9. Invasion of Destructive Organisms. Thermal pollutants may permit the invasion of organisms that are tolerant to warm water and are highly destructive. Invasion of shipworms into New Jersey's Oyster Creek constitute the best example. Shipworms could not survive in low temperature water but can grow in hot water.

10. Growth of Blue-Green Algae. Thermal discharges to a water course may favour the growth of blue green algae over green algae, resulting in a damage to ecosystem. Blue green algae are reported to be the poorer food source for aquatic animals. It may sometimes prove toxic to fish. As blue-green algae can convert a lake into marsh, it appears to be the indicator of **extreme thermal pollution**

conditions. These algae grow prolifically resulting in algal bloom inhibiting the growth of other aquatic organisms and produce foul odour in the receiving stream.

11. Longevity. High temperature of water may induce increase in activity which exhaust the organism and shorten its life. **Crustacean Daphnia** survives for 108 days at 7.8°C and 29 days at 21°C. Generally the speed of chemical change is doubled for every 10°C rise in temperature. **Mesophylic organisms,** which can thrive in a temperature range of 10° to 40°C severely affect the water quality.

12. Biochemical Oxygen Demand. When the temperature of the stream containing biodegradable matter rises, the intensified action of aquatic organisms causes the BOD to be accomplished at a lower temperature. Taste and odour problems initiated by temperature accelerated chemical or biochemical action are accentuated, when oxygen is depleted. Thus fish death may occur due to synergistic action.

13. Direct Mortality. Unutilized heat in water is responsible for direct mortality of aquatic organisms. The increase in temperature exhausts the micro-organisms and shortens their life span. Above a particular temperature, death occurs to fish due to failure in respiratory system, nervous system or essential cell processes. The lethal temperature for trout is 77°F above normal (about 90°F during summer). Any cold water fish will have to migrate to other areas in order to survive. Also many of planktons, small fish and insect larvae that are sucked into the condenser alongwith the cooling water are killed by the thermal shock, increased pressure and water viscosity.

14. Food Shortage for Fish. Temperature changes alter the abundances of micro-organisms, bacteria, protozoans etc. hence the fish may lack the food and die.

15. Affecting Distribution of Organisms. Distribution of aquatic organisms is influenced by the change in density, surface tension and viscosity of water. For example, planktonic organisms cannot compensate for pull of gravity in a less dense water and ultimately sink.

• CONTROL OF THERMAL POLLUTION

Control of thermal pollution is an extreme necessity, since in future its detrimental effects on aquatic ecosystem may be worse. To reduce the magnitude of the pollution, the outlet water can be made to give up some of its heat to the environment and then may be discharged into the water course. The following methods can be adopted to control the high temperature caused by thermal discharges.

1. Cooling Towers.

(i) Evaporative Cooling Towers. Cooling towers dissipate some of the heat from hot water to the surrounding atmosphere by the process of evaporation. Evaporative cooling towers are of two types :

(a) Natural Draft Towers. In these cooling towers, hot water is sprayed down through a rising current of air. The water vapour transfers its heat to the counter-current air and thereby gets cooled. The cold water is collected from the bottom and returned to the water system. The technique is, however, much expensive due to installation and operational high costs.

(b) Mechanical Draft Cooling Towers. The heated water flows in a system of pipes. Air is passed over these hot pipes by fans. Warm water, during its passage to water course, gets cooled by the action of air. The technique is also not desirable, since it creates annoyable noise due to the operation of fans. The cost involved is much higher than its usefulness.

Disadvantages of the Cooling Towers. Evaporative cooling towers generally cool the water by 10°C to 15°C only but they evaporate 2 to 5% of water in the atmosphere during the process thereby causing air pollution.

(ii) Non-evaporative Cooling Towers. In these towers, heat is directly transferred to the atmosphere by means of heat exchangers. This method is, however, not preferred due to fog formation in the vicinity of tower and the cost involved is also very high.

2. Cooling Ponds.

Cooling ponds or reservoirs constitute the simplest method of cooling thermal discharges. Heated effluents on the surface of water in cooling ponds maximize dissipation of heat to the atmosphere and minimize the water area and volume. By forming a warm water wedge over the cold receiving water, rapid heat loss to the atmosphere is encouraged by increasing the energy transfer due to evaporation, convection and back radiation. This warm water wedge acts like a cooling pond.

Advantages.

- Cooling ponds serve as a large settling basin.
- Low construction cost.
- It cools the water to a considerable low temperature.
- Beneficial for recreation purposes.

Disadvantages.

- The technique is less desirable and inefficient in terms of air water contact. The process cannot be applied on a stream inhabited by a cold water aquatic organisms and fishery etc.

3. Artificial Lakes.

Artificial lakes offer possible alternative to once-through cooling. The heated effluents can be discharged into the lake at one end and the water for cooling purposes may be withdrawn from the other end. The heat is eventually dissipated through evaporation. So these lakes would have to be rejuvenated continuously.

Other Control Measures.

- Prevention of thermal pollution in natural streams can be done through plant sitting, coupled with effective use of regulated river systems.
- Channeling of thermal effluents.
- Efficient designing of outfalls to prevent thermal block from occurring.
- Avoiding interferences of hot water mass with fish migration.
- Temperature prediction models can be used to develop the safe engineered designs.
- By improving the efficiencies of electric power generating plants.

Selecting a Site for Thermal Power Station to Control Thermal Pollution.

The impact of power station on the environment mainly depends on its location with respect to human population, meteorological conditions, agriculture, water bodies, forest lands and ambient air quality, etc. Following are the important precautions which are necessary to be taken while selecting an environmentally acceptable site for the thermal power station.

- The thermal power plant should atleast be 10 km away from the places of archaeological, historical, cultural, religious or tourists importance.
- The chimney of the thermal plant should not fall within approach funnel of the runway of the nearest airport.

- No forest or prime agricultural land should be utilized for setting up the thermal power station or for flyash disposal.
- The site for thermal plant should also be away from the defence installations.
- Location of thermal power stations should be atleast 25 km away from the outer peripheries of metropolitan cities, national parks, wildlife sanctuaries, important lakes and rivers etc.
- The residential and commercial developments should be regulated in the exclusion zone on the basis of strict land use planning.

• NUCLEAR POLLUTION

INTRODUCTION.

Today the vast and wonderful diversity of plant and animal kingdom that largely sustains the planet's ecological equilibrium is seriously endangered due to chronic radiation pollution. The main radiation hazard in the environment comes from ultraviolet, visible, cosmic rays and microwave radiations which produce genetic mutations in man. The biggest hazard comes from X-rays which account for 95% of our radiation exposure other than cosmic rays. Man has always been exposed to low levels of ionizing radiations from natural resources. But with the advent of nuclear weapons, exposure levels have increased enormously. The menace of radioactive pollution has raised extensively as a result of the discovery of artificial radioactivity, particularly due to the development of atoms bomb, hydrogen bomb and of techniques of harnessing nuclear energy. From neutron bombardment of atomic fuel, heavy radionuclides are produced which are extremely toxic. Once these radio-elements find access into the environment, they enter the ecocycling processes and ultimately into food chain and metabolic pathways.

The main issue that arises—**Is there any virgin environment that has not been exploited by man?** Every now and then we hear about a **Chernobyl type** of horrible disaster in the offing in our nuclear plants and the evils that aminocentesis has brought on the man. Nuclear science which has produced a host of beneficial peaceful applications, has also led to the piling up of nuclear arsenals capable of wiping out the entire humanity in a few seconds time. Even then are we desirous to control our nuclear power?

• CAUSES OF NUCLEAR POLLUTION

Living organisms are continuously exposed to a variety of radiation sources which are categorized into natural and anthropogenic sources.

NATURAL CAUSES OF RADIATION

1. Solar Rays

Solar rays coming from the sun keep a steady drizzle of gamma rays, cosmic rays and heavy particles. Solar storms vastly intensify these showers, but the earth's atmosphere shields us from most celestial radiations.

A. Electromagnetic Radiations. These radiations are highly energetic and include the following rays :

(i) X-rays (ii) Ultra-violet rays

(iii) Infrared rays (iv) Visible rays

(v) Gamma rays, and (vi) Radiowaves.

B. Particulate Radiations. Particulate radiations consist of proton, neutron, electron, alpha and beta particles. Cosmic rays become extremely intense

at about 20 km above the earth. A pilot receives 300 m rad per year of cosmic rays. People travelling by jet lines get an extra-exposure to cosmic rays.

2. Environmental Radiations.

Radio-isotopes of naturally occurring radio elements release enormous amount of radiations in the form of alpha, beta and gamma particles. Besides radio-isotopes, additional radiations emanate from air, soil, rocks and ground water. These radiations mix and interact with natural particulate materials in the atmosphere enhancing the extent of radioactive pollution.

3. Radionuclides in Earth's Crust.

Radioactive elements, such as U-238, Th-232, Ra-222 and K-40 which are widely distributed in earth's crust give rise to **terrestrial radioactivity.** The crops grown on such soil contain radioactive elements which are ingested in human body alongwith the food.

All these natural sources continuously pour their radiations into the environment. After all man has originated and evolved in a world of natural low level radiation. *We cannot avoid living in a sea of radiations.* Indeed our entire ecosystem hums with low levels of natural radiation.

ANTHROPOGENIC CAUSES OF RADIATION.

Recently man made sources have begun to add large doses of radiation to the existing natural radioactive pollution to which our bodies have got accustomed with several ill effects. The major causes are :

1. Medical X-rays.

Medical X-rays constitute about 18% of artificial radiations used in radiotherapy for diagnostic purposes. These rays are highly penetrating like the gamma rays. X-ray exposure is cumulative in the body and creates chronic defects in the internal organs.

2. Radio-isotopes.

Indiscriminate use of radio-isotopes administered to patients during radiation therapy, their overdoses and improper handling are hazardous sources of nuclear pollution.

3. Nuclear Tests.

During nuclear explosion test, a large quantity of long-lived radionuclides are released to the atmosphere, which get distributed all over the world. Radionuclides formed in explosion test include hazardous fission fragments such as Sr-90, Cs-137, Ba-141, I-131 along with unused explosives and activation products.

4. Nuclear Power Plants.

Nuclear power plants consist of nuclear reactors which utilize either plutonium or uranium as nuclear fuel to generate electricity by controlled chain reaction. In 2001, there were over 130 nuclear power plants in USA and more than 400 in rest of the world. The **major constraint** in the use of nuclear fission power is the yield of enormous quantities of radioactive fission waste products which remain lethal for thousands of years.

5. Nuclear Reactors.

Nuclear reactors generate various wastes like :

- Fission products remaining in both the primary and secondary fuels.
- Extraneous activation products in the coolant.

- Gaseous wastes of several nuclides comprising C-14, H-3, Xe-133, I-131, Kr-85, Ar-41.
- Liquid wastes containing H-3, Co-58, Fe-55, Co-59.

These nuclear wastes constitute an ever-increasing source of nuclear pollution. However, pollution from such sources is bound to increase in future, as more nuclear reactors are installed to meet the rising energy demands. No one can guess its disastrous effects that what would happen in a nuclear accident if the reactor core melts down.

6. Radioactive Ore-Processing.

Radioactive ores of uranium like pitch blende and uraninites as well as thorium are used in nuclear operations. Processes, *i.e.*, mining, washing, refining, separation and milling etc. cause nuclear pollution in the atmosphere. All these treatments during ore processing result in the release of radioactive gases which subsequently adsorb on the particles present in the atmosphere.

7. Industrial, Medical and Research use of Radioactive Materials.

Human activities have always resulted in some impacts on the environment, be these, for agriculture, deforestation, food, security, industrialization or technological developments. Rapid industrialization of power plants have resulted in devastating the virgin atmosphere. Leakage of nuclear radiations from reactors, plants and nuclear research laboratories result in radiation pollution. Radionuclides administered to patients during **medical diagnosis** used in radiation therapy and scientific research laboratories have proved to be the main source of nuclear pollution.

8. Radiation Pollution from Electric Fields.

Electrical gadgets and power transmission lines generate electric field causing environmental radiation hazard. Man is continuously exposed to such low frequency electric fields which are enough harmful.

• EFFECTS OF NUCLEAR POLLUTION

Detrimental effects of radiation became known as **1895** when **Wilhelm Roentgen** put his hand between X-ray tube and fluorescent screen. These rays penetrate deeply and the bones cast a deeper shadow than the flesh. In **1903**, the French Physicist **H. Becquerel** discovered naturally ray emitting elements and shared the **Nobel Prize** with **Madam Marie Curie**. M. Curie discovered radium, which is 25000 times more lethal than arsenic. The potency of radiation toxicity was realized by the death of M. Curie when she died of leukemia. Radiation poses a wide range of symptoms and syndromes causing several adverse effects.

1. Effects of Ionizing Radiations on Man.

Man is considered to be the final prey towards radiation effects and is at the end of all reactions and interactions. Ionizing radiation poses deadly cellular damage in man.

2. Effects of Non-ionizing Radiations.

Modern life and radiations seem to increase the risk of radioactive pollution. Of all the non-ionizing radiations including infrared, radiowaves, microwaves, radar etc., the action of ultraviolet (UV) radiation has been extensively studied.

Effects of UV Radiations.

- UV radiations are thought to trigger two distinct immunological effects. One is confined to patches of skin that are actually irradiated while the other damage is caused to the immune system as a whole.

- UV radiations cause leukemia and breast cancer, although the reasons are obscure. According to an estimate nearly 7000 people die of such cancers in USA every year.
- UV rays can also be absorbed by lens and cornea in the eye leading to photo-keratitis and cataracts. Since the radiation is not sensed by the visual receptors of eye, the damage is done without the individual knowing about its hazards.
- UV radiations also affect drastically the micro-phytoplanktons. Increased UV rays will increase the mortality rate of larvae of zooplanktons in water. Enhanced radiation also impairs the fish productivity.
- Plants absorb strongly the light near 280 nm. So plant proteins are more susceptible to UV injury. In plants 20% to 50% chlorophyll reduction and harmful mutations are seen.

3. Effects of Microwave Radiation.

- Microwaves between 10 to 30 cm can penetrate the epidermis and fat layer of the skin, while the waves longer than 30 cm can penetrate deep tissues of dermis causing the skin hot.
- The eyes and other organs that cannot dissipate heat are most vulnerable to microwave radiations. Microwaves cause pearl chain effect where particles align in chain when subjected to an electric field.

Radar Hazards. The radar hazards cause headache, nervousness and skin diseases.

4. Biological Effects of Radiation.

- Eye lens is vulnerable to high doses of radiation. It damages eye cells so that the eye lens becomes opaque forming cataract which impair sight.
- Cumulative radiation sickness is marked by vomiting, bleeding of the gums and mouth ulcers in man.
- High doses of radiation cause internal bleeding and blood vessels damage which become evident as red spots on the skin.
- Acute nausea and vomiting begin within few hours after the gastro-intestinal tract is exposed.
- Embryos get critically damaged. Unborn children are especially vulnerable to brain damage or mental retardation, if irradiation occurs during formation of central nervous system in early pregnancy.
- Cumulative doses acutely damage the reproductive organs like ovaries and testes that may badly affect the victim's fertility as well as their offsprings.
- High radiation doses cause damage to bone marrow : the **body's blood factory.** It is specially dangerous because it retards body's ability to fight against infection and haemorrhaging by harming the white blood corpuscles.
- The short term damage may include anaemia, fatigue, blood, kidney and liver disorders, epilation, skin changes including erythema, pigment discoloration and premature aging.

Delayed Biological Effects of Radiation.

Delayed biological effects are mainly of two types, *i.e.*, Somatic or non-genetic effects and Genetic effects.

A. Somatic or Non-Genetic Effects. Somatic effects include changes in the body cells which are not inherited with next generation. These effects are the direct results of radiation action on the body cells and tissues in man which show immediate or delayed symptoms.

- The victim declines in vitality and dies from anaemia, blood cancer and haemorrhage.
- Chronic somatic effects include thyroid changes, bone deformities, bone necrosis, cataract of the eye, bone sarcoma, epidermis damages including erythema, atrophy, alopecia and ulceration. The victim also suffers from lung diseases, that is, fibrosis, lung cancer, malignant tumors, cardio vascular disorders and ultimate reduction in life span.

B. Genetic Effects of Radiation. Genetic effects of radiation include gene mutations and chromosome abnormalities, which are transmitted to the next generation. Genetic effects generally imply inheritable changes in the reproductive cells. Radiation causes damage to the germ cells in two ways :

(i) Lethal mutations called genetic death,

(ii) Non-lethal mutations.

- Acute doses of radiation affect the reproductive organs, so the gametes produced contain deleterious gene mutations which are carried in the unborn children.
- Radiation causes disintegration within the gametes so that genetic mechanism of chromosomes become damaged.
- Disorderly genetic effects may lead to the death of embryo, neonatal death or may cause birth of defective offsprings.

Mutagenic Effects of Radiation. Radiation can induce ionizing and photochemical reactions in DNA molecules causing them to mutate. Mutation is a sudden and stable inheritable change in chromosomal or non-chromosomal (as chloroplast and mitochondria in plant) deoxyribo nucleic acid (DNA).

5. Effects of Laser Radiation.

Light amplification by stimulated emission of radiation (Laser) in gaseous systems was first reported in 1961 in a helium neon mixture. CO_2-laser and He-lasers are used in surgery. The latter is particularly useful for percutaneous myocardial revasculation (PMR). UV lasers cause photophobia, erythema, exfoliation of surface tissues.

In case of IR laser radiation damage results from surface heating of cornea. Visible lasers (wavelengths of 0.4 to 0.75 nm) hit the epithelium of the retina. At extremely high powered laser radiation (*e.g.*, Q-switched pulses), depigmentation of skin, erythema, blistering and charring occurs. Important control principles to protect from exposure to laser systems include imparting awareness to people concerned regarding potential hazards, applying primary engineering and other controls, *e.g.*, enclosure, beam stops, shutter; using shielding and safety goggles.

6. Radiation Effects on Plants.

Radiation effects are generally common to plants and animals. Small amounts of radionuclides may lead to an increase in the rate of mutation in plants also. Radioactive elements accumulate in soil, sediments, air and water. Lethal doses or radioactive fall out materials (Sr-90 and Cs-137) reach man *via.*, the food chain.

- Intense radiations kill plants but differently. Trees and shrubs vary in their reactivity and sensitivity towards radioactive substances. This variation is mainly due to the difference in chromosome number and size. However, a chronic dose of 1 R per day continued for 10 years causes so much growth reduction in pines as an acute dose of 60 R.
- Studies revealed that after the disastrous **Chernobyl** accident, the herbs, plants, soil and reindeer herds of **Sweden** and **Norway** were showered with radioactive rain for several days. Today the lichens—the people eat are contaminated with radionuclides.

In **coastal Kerala**, between Charava and Neendakara, the soil contains monazite having radio-active element, thorium. As a result of this, the back ground radiation is quite high, *i.e.*, 1500 to 3000 milli roentgens (mr) per year.

• CONTROL MEASURES OF NUCLEAR POLLUTION

With the present endeavors for improving the comforts and standards of living on one hand and for meeting growing demands of energy from natural resources, much longer term impacts of radiations in the coming years are inevitable. So there is a dire need to look for sources other than the conventional ones to control radiation hazards.

Also preventive measures from radiation should be double edged so as to curtail the effects of both natural radiation and artificially produced occupational exposure. **Following control measures should be adopted.**

1. Nuclear devices should never be exploded in air. If these activities are extremely necessary then they should be exploded underground.

2. In nuclear reactors, closed-cycle coolant system with gaseous coolants of very high purity may be used to prevent extraneous activation products.

3. Containments may also be employed to decrease the radioactive emissions. It can be achieved by using tightly sealed boxes and closed cycle systems.

4. Production of radionuclides should be minimized, as once produced they can not be rendered harmless by any means except the passage of time.

5. Fission reactions should be minimized as the rate of decay of radionuclides and subsequent emission of radiations are unaltered by man.

6. In nuclear and chemical industries, the use of radio-isotopes may be carried under a jet of soil or water instead of powder or gaseous forms.

7. In nuclear mines, wet drilling may be employed alongwith underground drainage.

8. Extreme care should be exercised in the disposal of industrial wastes contaminated with radionuclides.

9. Using high chimneys and ventilators at the working place where radioactive contamination is high. It seems to be an effective way for dispersing radio-pollutants.

10. Nuclear medicines and radiation therapy should be applied when absolutely necessary with minimum doses.

11. Protection from internal irradiation can be done by using regular protective clothing (overalls, cap, gloves, slippers) while performing experiments. While decontaminating glove boxes, use is made of respirator and plastic overalls etc.

In case of an accident :

(i) *Localise the place of accident.*

(ii) *Check the contamination of the overalls, hands and body.*

(iii) Radioactive liquids should be gathered with a sorbing material such as paper, waste, saw dust etc. into a special vessel. Wash the contaminated surface with a decontaminating solution. In decontamination, perform radioactive monitoring of the washed and contaminating sections. The decontaminating solution may be of ethanol or acetone or 10% solution of detergent in water.

12. Collect the radioactive powder with wads wetted in mineral oil.

13. Minimum number of nuclear installations should be commissioned as it is a fruitful measure to limit the emission of radio-pollutants.

14. During nuclear installations, various efforts, including the process of site selection, its design, construction, commissioning, operation, decommissioning, its short and long term effects etc. should be seriously considered to control radiation.

15. Environmental parameters such as micrometeorological data, hydrological data, identification of critical group of population likely to be most exposed to radiation, foundation conditions and seismicity of the region should be undertaken before selecting and constructing a major nuclear industry.

16. The pre-operational data so collected should be used to set the limits of release of radioactive gases. The monitoring stations should carefully monitor the release of radio-isotopes during nuclear power installation.

17. The recipient sectors of the environment with their safe capacities to accept the radio-toxins must be identified.

18. Maximum efforts need to be put into making solar energy and fusion reactors feasible, not only to meet our energy requirements but also to minimize our dependence on present day fusion-fission based nuclear reactors.

19. Main prophylactic measures include : The equipment, technological conditions, rational system of ventilation and disposal of radio-waste.

CONTROL OF OCCUPATIONAL RADIATION EXPOSURE.

In case of occupational radiation exposure, individual contamination is much severe. Following steps may be adopted to control external radiation hazard.

- Radioactive operations may be carried out by remaining at a sufficient distance from the source.
- For persons working with radioactive materials in nuclear industry it is difficult to reduce the radiation hazard. So duration of exposure may be shortened by performing the operations quickly and working in shifts.
- Shielding can minimize the radiation dosage while working with radionuclides.

MINIMIZING X-RAY HAZARDS.

There is a general tendency among medical practitioners to stretch the use of X-rays as a diagnostic tool. The patient is X-rayed for the same investigation in more than one hospital. To minimize X-ray hazards, following steps need to be considered.

- A patient receives much larger dose during screening than while performing a radiographic procedure. Minimum screens should be taken to reduce the harm.
- X-ray screening can be replaced by radiography. In unavoidable cases, modern screening aids like image intensifiers could be used.
- Screening units should always be fitted with a fluoroscopic timer and should be strictly under radiological surveillance.
- Today numerous diagnostic modalities are available which do not involve any ionizing radiation and are harmless. Magnetic resonance imaging and ultrasonography are the recent diagnostic techniques that may yield more accurate information than the ionizing radiations.

• SOLID WASTE MANAGEMENT

Any unwanted or discarded material from residential, commercial, industrial, mining and agricultural activities that cause environmental problems may be termed as solid wastes. **Solid waste management** comprises of systematic control of the generation, storage, collection, separation, treatment, processing, recycling, recovery and disposal of solid wastes.

Classification of Solid Wastes.

1. Municipal Solid Wastes (MSW). MSW include garbage and rubbish from households, hotels, offices, markets etc. Garbage denotes biodegradable food wastes while rubbish is used for non-biodegradable wastes which may be combustible (*e.g.*, paper, plastic, tyres) or non-combustible (*e.g.*, glass, metals, used containers etc.)

2. Industrial Solid Wastes. These wastes are :

(i) Process waste which depend upon the type of the products being manufactured such as tannery wastes, food processing wastes, plastic and rubber waste etc.

(ii) Non-process wastes like packing waste, cafeteria wastes are common to all industries.

3. Biomedical Solid Wastes. BMW includes pathological and surgical wastes.

4. Agricultural Wastes. These wastes result from farms, feed lots and livestock yards. Horticulture wastes consists of vegetable parts.

Other Wastes.

Construction/demolition wastes include debris, rubbles, wood, concrete etc.

- **Radioactive** hazardous wastes are from nuclear power plants and laboratories etc.
- **Electronic** wastes originate from discarded electronic devices such as TV, computers.

The **annual solid waste production** in India is : Domestic and trade (8.5%), industries (15.2%), thermal power stations (7.3%), mining (67%) and construction (2%).

Effects of Solid Wastes.

Municipal solid wastes heap up on the roads due to improper disposal system. Open dumping allows biodegradable materials to decompose under unhygienic conditions. This produces foul odour and breeds disease vectors and infectious pathogens beside spoiling the aesthetics of the site.

- Industrial solid wastes are the sources of toxic metals and hazardous wastes which may leach or percolate to contaminate the ground water.
- The hazardous wastes are mixed with garbage and other combustible waste. This makes segregation and disposal more difficult and risky. Various types of wastes like cans, pesticides, solvents, radio-isotopes, plastics, etc. are mixed with paper, scraps and non-toxic materials which could be recycled. Burning of these waste produce furans, dioxins, poly chlorinated biphenyls which have the potential to cause several ailments including cancer.

MANAGEMENT OF SOLID WASTES.

Objectives. The aim of waste management is to collect, treat, utilize, control and dispose solid waste in an economic manner consistent with the protection of

public health. Its major consideration apart from health is to adopt three R's-reduce, reuse and recycle strategy.

(i) Reduction in use of raw materials. This will correspondingly decrease the production of waste. Reduced demand of any metallic product will decrease the mining of their metal and cause less production of waste.

(ii) Reuse of waste materials. Reuse of paper, cardboard, glass, metal, plastic, discarded cycle tubes, autoparts of vehicles considerably reduces the waste of generation.

(iii) Recycling of materials. Recycling is the reprocessing of discarded materials into new useful products. Examples include formation of new cans, bottles from broken aluminium cans and glass, fuel pellets from kitchen waste, cellulose from waste paper, ethanol from bagasse etc. Coal ash, the residue left after coal combustion for power generation, is an important source of ferrosilicon, silicon and aluminium.

One tonne of solid waste processed by pyrolysis is believed to yield an energy equivalent to one barrel of oil. One tonne of combustible waste produces energy equal to 9 million BTU of heat or 65 gallons of fuel oil or 9000 cubic feet of natural gas.

MUNICIPAL SOLID WASTE TREATMENT.

Composition of MSW. The average composition of MSW is : 30 to 40% organic matter, 30 to 40% fine materials, 5% paper, 1% glass, 1% metals and 1% plastic. Actual composition of MSW varies demographically. For discarding wastes, following treatment methods are adopted.

1. Sanitary Landfill. In sanitary landfill operation, garbage is spread in thin layers compacted and covered with clay or plastic foam. In the modern landfills, the bottom is covered with an impermeable liner, usually several layers of clay, thick plastic and sand. The liner protects the ground water from being contaminated due to percolation of leachate. Leachate from bottom is pumped and sent for treatment. When landfill is full it is covered with clay, sand, gravel and top soil to prevent seepage of water. Methane produced by anaerobic decomposition is collected and burnt to produce electricity or heat.

Other methods of landfill treatment are sewage farming, spray irrigation, ridge and furrow and lagooning etc. **In India**, there exists **200 sewage farms** covering 25000 hectares and using 650 million gallons of sewage per day.

With increase in urbanisation, planned sanitary landfill, backed by modern solid waste management, can provide the community with better environmental management.

2. Composting and Municipal Waste Composting Projects. Composting is the aerobic and thermophilic decomposition of organic waste to humus by micro-organisms like bacteria, fungi and worms. The process is conducted by a complete **automatic system. (i)** The crude refuse is dumped into a container or to a belt conveyor. **(ii)** Iron or metallic particles are removed by a magnetic separator. The wet material is then transferred to a rotatory cylinder which rotates on large tyres. Here aerobic microbes rapidly decompose pulverized wastes under aerobic conditions. The Government encourages feeding of compost plants by municipal wastes. Compost has been used by Indian Agricultural Research Institute to produce blue-green algae coated granulated compost.

3. Vermi Composting. In vermiculture, earthworms feed on and degrade a variety of organic waste, eliminate noxious elements and convert the waste into high grade nutrient rich vermi-compost. It is very useful biofertilizer and soil conditioner.

4. Incineration. Incineration involves burning of solid wastes at high temperature either on batch or continuous type incinerators. The **modern municipal incinerators** are of continuously burning type. These are equipped with large storage bins, automatic feed hoppers, moving grates, ash discharging systems, pollution control devices like scrubbers and electrostatic precipitators. The unit yields stable residue free from offensive odours. The waste heat of combustion can be utilized for supplementing electricity generation for domestic heating etc. However, the technique involves expensive equipment.

INDUSTRIAL SOLID WASTE TREATMENT.

1. High Temperature Incineration of Industrial Solid Waste. It is a recent innovaton where high temperature (~1650°C) is attained using supplementary fuels. The non-combustible fractions of the refuse (metals, glass) can be melted and reused.

2. Pyrolysis. The combustible constituents of the solid wastes are heated in a pyrolysis reactor at 1000°C in a low oxygen environment. Pyrolysis of the waste yields several components such as methanol, acetone, H_2, CH_4, CO_2, carbon char and inert materials (glass, rock, metals). Advantage include handling of hazardous plastics (PVC) in a safer way.

3. Vitrification. The recent insitu vitrification aims at converting glass, plastic, muck, mud and other wastes (except radiowaste) into glass like solid.

BIOMEDICAL WASTE.

Biomedical waste (BMW) are generated by hospitals, clinics, dispensaries and blood banks during diagnosis, treatment or immunisation of human beings and animals. Considering the highly infectious and toxic nature of BMW, **Government of India** has passed Biomedical Waste (Management and Handling) Act in 1998 which was amended in 2000. The Act emphasizes on the safe disposal methods to be strictly followed by the hospitals.

About 80% of BMW are comparable to domestic waste. The remaining 20% is hazardous. Improper disposal or dumping of BMW may cause pollution of air, water and soil. The hazards could be avoided if BMW is disposed properly.

Treatment Methods of BMW.

Treatment methods include chemical disinfection, deep burial, thermal deactivation, radioactive irradiation, microwaving, autoclaving, incineration, electron beam sterilisation and plasma pyrolysis etc.

Incineration of BMW. The common practice for handling BMW is the on-site incineration in a specially designed double chambered incinerator at 800°C and 1050°C. The thermoclave installed in the plant can treat 150 kg of waste per hour at high pressured steam and remove toxic dioxins, poly chlorinated biphenyls and H_2SO_4 etc.

Biomedical waste from such hospitals which do not have facilities for incineration or pyrolysis are segregated, packed in coded and labelled containers and transported to a place where such facilities exist.

• ROLE OF AN INDIVIDUAL IN PREVENTION OF POLLUTION

The role of every individual in preventing pollution is of paramount importance because a small effort made by him will have pronounced effect at the global level. It is aptly said, **Think globally act locally.** Each individual should change his life style in such a way so as to reduce environmental pollution. It can be done by

following suggestions.

- Lay greater emphasis on pollution prevention than pollution control.
- Use ecofriendly products like degradable paper bags instead of polyethylene bags.
- Promote 3R strategy of reduction, reuse and recycling of wastes.
- Adopt renewable resources of energy.
- Save electricity by not wasting it when not required.
- Reduce dependence on fossil fuel especially coal or oil.
- Cut down the use of chloro fluoro carbons (CFCs) as they deplete the ozone layer.
- Use chemicals derived from peaches and plums to clean computer chips and circuit boards instead of CFCs.
- Air pollution can be prevented by using solar powered hydrogen fuel.
- Use phosphate free or biodegradable detergent and shampoo. This will reduce eutrophication of water bodies.
- Do not put pesticides, paints, solvents, oils and chemicals into drain or ground water.
- Use biofertilizers and organic manure instead of commercial fertilizers.
- Use less hazardous chemicals wherever their application can be afforded.
- Use rechargeable batteries which will reduce metal pollution.
- The solid waste generated during one manufacturing process can be used as a raw material for some other processes.
- Do not litter polythene bags.
- Plant more trees as trees can absorb many toxic gases and purify the air by releasing oxygen.
- Check population growth so that demand of materials is under control.

• POLLUTION CASE STUDIES

AIR POLLUTION EPISODES.

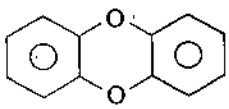
A series of air pollution episodes have occurred from Meuse Valley, Belgium (1930) to Chernobyl nuclear disaster in USSR (1986).

Donora Air Pollution Disaster.

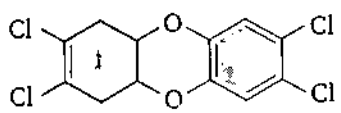
Donora Pennsylvania is a small mill town. It lies in a horse shoe shaped valley on Monogahela river, USA, south of Pitsburgh with steep hills on each side of the river. A four day fog occurred in October 1948 due to pollutants (SO_2) emitted by steel mills, zinc smelter and sulphuric acid plant. Owing to anticyclonic weather conditions, there was no air movement and temperature inversion had set in due to sea breeze conditions. About 40% people fell ill and some of them died.

TCDD Disaster at Seveso, Itlay.

In July 1976, a white cloud of poisonous gas consisting of 2, 3, 7, 8 tetrachloro benzo-10-dioxin (TCDD) exploded in a herbicide (2, 4, 5-trichlorophenoxy acetate) manufacturing chemical plant. It engulfed the nearby town of Seveso and contaminated over buildings, grounds and soil. About 800 people were evacuated



Dioxin (Dibenzo-*p*-dioxin)



TCDD (2, 3, 7, 8-tetrachlorobenzo-10-dioxin)

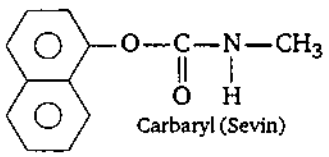
from the worst affected places by the Italian government. Nearly 200 people suffered from respiratory, eye, gastrointestinal and liver diseases. The worst victims were pregnant ladies who gave birth to deformed and premature babies. According to researchers, dioxin will continue to contaminate soil, air and water which will choronically pollute water resources and natural biological processes.

• THE BHOPAL GAS TRAGEDY (THE CITY OF DEATH)

Venue. Bhopal, Madhya Pradesh, India.

Industrial disaster date. December 3, 1984.

Source. Union Carbide Factory, manufacturer of Carbaryl (carbamate pesticide) using methyl isocyanate (MIC).



Carbaryl (Sevin)

CH_3NCO
Methyl isocyanate (MIC)

The Tragic Incident. December 3, 1984 was a chilly windy night of macabre death when a killer cloud of MIC gas converted the night at 11 p.m. into a night mare of misery, panic and sickness on Bhopal city with a population of 800,000. The safety valve remained open for two hours releasing over 50,000 lbs of MIC associated with $COCl_2$ and HCN.

Safety Devices and Violent Reaction.

The two safety devices for neutralising leaking MIC, *viz.*, the vent gas scrubber and the flare tower were non-functional. Moreover, the refrigeration unit connected to MIC storage tanks, which keeps the liquid at 0°C, had been closed down since June, 1984. As a result the gas was at 15°C. In a closed tank, the pressure due to reactions of MIC with H_2O or catalyst can build up to the point that safety valves will open, venting both MIC and phosgene ($COCl_2$) gas.

Misery, Panic and Death Drama. Between 12.30 and 1 a.m., people woke up coughing violently and with their eyes burning as if chilli powder had been sprayed into them. The deadly poisonous gas spread over 40 sq. km. seriously affecting the people up to a distance of 5 to 8 km. An estimated 500,000 people fled that night, most on foot.

In Jai Prakash Nagar every thing was so quiet-thousands lay dead on the roads and in homes. Corpses with distended bellies were beginning to rot. More than 2000 people lay dying in Hamidia hospital. By 1 a.m. on December 4, 1984 the hospital was crowded by 25,000 patients. The death drama continued for four days. More than 100,000 injured people were treated with limited medical care. Many people sat in silence, blinded and mained by unknown enemy. Within a week about 10,000 people died while more than one lakh people continue to suffer from various disorders. By December 13, 1984 about 1 lakh people left the city.

Neutralization Drama—Operation Faith.

The task of disposing off the balance MIC in the storage tanks was entrusted to the Director General of CSIR. It was decided to convert MIC into the final product, carbaryl. On December 16, the factory was started to restore faith among people. The operation ended on the seventh day and 24 tonnes of MIC had to be converted, 50% more than that was estimated.

The Aftermath. A medical survey held 100 days after the MIC exposure revealed that out of 250,000 people exposed, 65,000 were subjected to severe medical disability (respiratory, eye, neuromuscular, gastrointestinal,

gynaecological symptoms) and 50,000 to mild disability. People suffering from breathlessness, digestion and sleeping problems are incapable of carrying on even light physical labour and unable to earn a living. Pregnant women were the worst victims.

Update about Bhopal Disaster.

Recent reports indicate that about 28,000 gas victims have died so far while an estimated 10 to 15 people are dying every month from exposure related ailments. More than 1,20,000 survivors are said to be still suffering from a variety of chronic diseases including respiratory tract problems, lung diseases, hypertension, anxiety, diminished vision, acute depression, muscular fatigue, recurrent fever, gynaecological disorders. The gas victims have not got proper medical care even after Rs. 250 crores have been spent for the purpose by the government. Thousands of people living in shanty towns near the factory complex are forced to drink toxic water because of the contamination of water table and soil. The State government has not provided clean drinking water to the gas victims although Rs 70 crores have been spent for environment upgradation. The **NGO Green peace** described the factory site as a **global toxic hot spot**. Finally, the Supreme Court directed the Government (July 19, 2004) to release Rs. 1,500 crore of Union Carbide money to the victims of gas leak.

Lesson. Now Bhopal holds out lessons that have to do with basic human concerns for safety, for standards and for good sense. If the lessons are lost, then it is possible that accidents such as this may be repeated in another factory, in another city, in another way.

• LOVE CANAL EPISODE

The Love Canal in Niagara Falls, New York was used to dump sealed steel drums of chemical waste by Hooker Chemicals and Plastics Corporation during 1930–1953. In 1953, the dump site was capped with clay and sold to the city Board of Education which built an elementary school. Houses were also built near the school. In 1976, the residents started complaining of foul smell and illness. The leachate penetrated in the area. In 1978, the state and federal official surveyed air samples in the basement of houses and identified some 26 toxic organic compounds. The President of USA declared Love Canal as an emergency disaster area and relocated the affected families. The clean up of the canal and stabilization of the area costed over 40 million dollars. Love Canal episode is only the tip of an ice-berg and several other dump sites may exist in the third world countries.

Arsenic Pollution in Ground Water.

West Bengal and Bangladesh are severely affected by arsenic contamination in ground water. The first incident was reported in 1978 in West Bengal and that of Bangladesh in 1993. Arsenic in ground water was found above maximum permissible limit (0.05 ppm) in six districts of West Bengal covering an area of 34,000 sq. km. with a population of 90 million. At present, 37 administrative blocks by the side of river Ganga are affected. The 24 Paraganas, Hooghly, Malda, Murshidabad, Bahela and south eastern fringes of Kolkata lie in **arsenic risk zone.** People drinking such water have shown arsenical clinical manifestations like melanosis, hyperkeratosis, bronchitis, discolouration of skin, gangrene in limbs etc.

Bangladesh with 64 districts covering an area of 65,000 sq. km. lie along the Padma river. About 50 million people are exposed to arsenic contamination. Sediments derived from metamorphic rocks and excessive use of pesticides (lead arsenate, copper arsenite,etc.) seem to be the major cause of arsenic pollution.

• DISASTER MANAGEMENT

Disasters like earthquakes, floods, cyclones, hurricanes, volcanoes and landslides are the extreme events which exceed the tolerable magnitude and result in catastrophic losses of lives and human settlements. Human societies have witnessed a large number of such hazards and have tried to control them to some extent.

EARTHQUAKES.

Earthquakes occur due to sudden movement of earth's crust. The earth's crust has several tectonic plates of solid rock which slowly move along their boundaries. When friction prevents these plates from slipping, stress build up and results in sudden fractures which can occur along the boundaries of the plates or fault lines (planes of weakness) within the plates. This results in earthquake, the violent short term vibrations in the earth. The point on a fault at which first movement occurs during an earthquake is known as **epicentre.** The seismic waves move away from the source of earthquake which can be recorded by **seismometer.** The severity of an earthquake is generally measured by its magnitude on Richter scale devised by Charles Richter (1935).

Richter scale	Severity of earthquake	Richter scale	Severity of earthquake
Less than 4	Insignificant	6–6.9	Destructive
4–4.9	Minor	7–7.9	Major
5–5.9	Damaging	More than 8	Disastrous

- The **largest** earthquake ever recorded occurred on **May 22, 1960** in Chile with the magnitude of 9.5 on Richter scale. It affected 90,000 square miles and killed 6000 people.
- A devastating earthquake hit Bhuj town in Gujarat on January 26, 2001. It caused massive damage and killed 25,000 people. It had an energy equivalent to 5.3 mega tonne hydrogen bomb.
- Earthquake generated high seismic waves called **tsunamis** can severely affect coastal areas. These giant sea waves move at a speed upto 1000 km/hr or even faster. While approaching the sea shore they may often reach 15 m or upto 65 m in height and cause massive devastation.
- In China tsunami killed 8,30,000 people in 1556 and 50,000 in 1976.
- Very recently, on **March 11, 2011,** the most devastating undersea earthquake (tsunami) occurred in Japan measuring 9 on Richter scale. It inundated coastal areas and caused explosion in nuclear reactor.

Anthropogenic Activities Enhancing Earthquakes.

- Collection of huge quantities of water in the lake behind a big dam.
- Underground nuclear testing. Deep well disposal of liquid waste.

Effects of Earthquakes.

- Earthquakes cause heavy loss to life, property, buildings, bridges and roads.
- Disrupt telecommunication systems, water and electricity supply.
- Severe tremors damage dams resulting in floods.

Mitigation of Earthquake's Effects.

- By constructing earthquake resistant buildings by strategically placing weak spots to absorb vibrations or by placing pads or floats beneath the buildings.
- By making wooden houses in seismic zones.

• CASE STUDY—THE ASIAN TSUNAMI IN 2004

The **Indian Ocean earthquake,** called Tsunami (meaning harbour wave) which occurred on December 26, 2004 is one of the deadliest disasters in the history. It was a devastating undersea earthquake measuring between 9.1 and 9.3 on Richter scale with an epicentre off the west coast of Sumatra and Indonesia. It triggered a series of tsunamis and shook 1000 km of the seabed. The sea water was shaken violently and the sea waves, 40 feet high spread at a speed of 700 km/hr (speed of jet plane). The **seaquake** inundated coastal communities across south and south-east Asia including parts of Indonesia, Sri Lanka, Thailand, Tamil Nadu, Kerala, extending over 1200 km area. About two lakh people died and caused damage of properties worth $ 40 billion (Rs. 2 lakh crores).

It was the **second largest seaquake** with longest duration of faulting, lasting between 500 and 600 seconds, that caused the entire planet to vibrate about a centimetre. India's tectonic plate clashed with Myanmar (S.E. Asia) plate in ocean at a depth of 24000 feet near Sumatra islands of Indonesia. The fault line slipped about 15 m involving the formation of rupture 400 km long and 100 km wide. The total energy released has been estimated at 3.35×10^{18} joules equivalent to that of 10,000 atom bomb explosions.

A tsunami which causes damage far away from its source is known as **teletsunami**, produced by vertical motion of the sea bed rather than by horizontal motion.

Environmental Aspects.

- Besides heavy toll on human lives, tsunami has caused enormous environmental impact. Severe damage to ecosystems like coral reefs, mangroves, coastal wetlands, sand dunes and forests has been noticed.
- Other adverse effects caused by tsunami include mixing of salt with sewage water, invasion of aquifers through porous rock, deposition of a salt layer over agricultural land damaging plants and soil micro-organisms.

Warning System.

Tsunami can not be prevented because it originates in deep water and has a little height. Costly network of sensors is needed to detect a tsunami. Pacific ocean experiences more frequent tsunamis in the **Ring of Fire** and has a warning system there.

• LANDSLIDES

Landslide is the moving down of coherent rock of soil mass by the combined action of water and gravity. Rain water creates hydraulic pressure that increases the weight of rocks at cliffs which come under the gravitational force and slide down. Vegetation also influences landslides. It consolidates the slope material, provides cohesion by its root system and also retards the flow of water and its erosion capacity.

However, this can be masked by many other exerting factors like :

- Earthquakes and vibrations etc.
- Saturation of the unconsolidated sediments with water.

Causes of landslides. Anthropogenic activities like hydroelectric projects, large dams, reservoirs, mining, construction of buildings, roads and railway lines etc. make mountain slopes fragile leading to landslides. Landslides increase the turbidity of nearby streams reducing their productivity.

Mitigation of landslides. Landslides can be minimized by stabilising the slope by :

- Draining the surface and subsurface water.
- Providing solid support by wired stone blocks.
- Concrete support at the base of a slope.

Table 5 shows occurrence of natural disasters in India.

Table 5. Natural disasters occurring in India.

Type	Location/Area	Affected population (in million)
Landslide	Entire sub-Himalayan region and Western Ghats.	10
Floods	8 Major river valleys spread over 50 million hectares.	264
Cyclones	Entire 5700 km long coastline of southern peninsular India covering 9 states, *viz.*, Kerala, Tamil Nadu, Andhra Pradesh, Orissa, West Bengal, Gujarat, Goa, Maharashtra, Karnataka and Union Territory of Pondicherry besides Islands of Andaman and Nicobar.	11
Earthquake	Nearly 55% of the total area of the country falling in the seismic zone IV and V.	400
Drought	Spread in 14 States covering 116 districts and 740 blocks, *viz.*, Andhra Pradesh, Bihar, Gujarat, Haryana, Jammu and Kashmir, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Rajasthan, Tamil Nadu, West Bengal and Himachal Pradesh, Uttar Pradesh.	86

• CYCLONES

Cyclones are recurring phenomenon in the tropical coastal regions. Tropical cyclones are the most powerful and destructive storms on the earth. These cyclones move like a spinning top at the speed of 10 to 30 km per hour. They can last for a week or so and have a diameter varying between 100 to 1500 km. Tropical cyclones originate when the sea surface temperature is above 25°C. These are called **hurricanes** in Atlantic, Caribbean and north eastern Pacific, **typhoons** in the western Pacific and southern coast of China, Japan and Phillipines, **cyclones** in Bangladesh and Indian oceans, **willy willies** in the sea around Australia.

Effects. Tropical **cyclones** become more disastrous because of the their high speed, high tidal surges, high intensity of rainfall and very low atmospheric pressures causing unusual rise in sea level. Sea water with combined force rushes and inundates the low lying areas. **Hurricane winds** (74 miles/hr), rains and storm surge (often 50–100 miles wide dome of water) devastate the area where it strikes on land. The devastation is severe when storm surge and normal astronomical tide coincide.

Management Measures. It is difficult to avoid the recurrence of cyclones. Following defence measures can minimise the severity of cyclones.

- Tree plantation on the coastal belt.
- Construction of dams, dykes, embankments, storm shelters and wind breaks.
- Proper drainage system and wide roads for quick evacuation.

• CASE STUDY—HURRICANE KATRINA

Hurricane Katrina struck Gulf coast of USA, Louisiana and two other states, Mississippi and Alabama on August 28/29, 2005. It started as a tornado followed by a storm surge hurricane at 140 miles/hr. The sea wave, 9 feet high, splashed on the shores, blowing away houses, flooding cities which remained under 5 feet of water

for 7 days and killing 25,000 people. New Orleans (Louisiana) looked like a giant wasteland and simmering under 35°C heat of apocalyptic late summer. The cities resembled Baghdad (Iraq) devastated by war but in this case, nature unleashed destruction on USA. There was biggest evacuation of people in US history to adjoining states-Colorado and Texas.

Mass panic. The scenario of misery, poverty of black Americans and helplessness of even the US administration revealed the third world part of USA before the world.

Total damage was 25,000 deaths, 50,000 injured and property worth $ 100 billion.

Environmental impacts. The storm and waves completely obliterated the Chandeleur Islands. About 20% of the local marshes were permanently destroyed. Sixteen National wildlife Reserves were forced to be closed due to Katrina amongst which Breton National Wildlife Refuge suffered maximum damage.

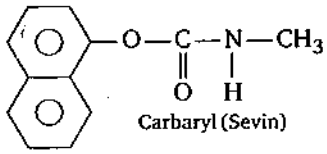
During the clean up effort, the flood waters from New Orleans were pumped into lake Pontchantrain, which were contaminated with sewage, several toxicants, pesticides and oils posing serious threat to aquatic life.

• CASE STUDY—THE BHOPAL GAS TRAGEDY (THE CITY OF DEATH)

Venue. Bhopal, Madhya Pradesh, India.

Industrial disaster date. December 3, 1984.

Source. Union Carbide Factory, manufacturer of Carbaryl (carbamate pesticide) using methyl isocyanate (MIC).



Carbaryl (Sevin)

CH_3NCO
Methyl isocyanate (MIC)

The Tragic Incident. December 3, 1984 was a chilly windy night of macabre death when a killer cloud of MIC gas converted the night at 11 p.m. into a night mare of misery, panic and sickness on Bhopal city with a population of 800,000. The safety valve remained open for two hours releasing over 50,000 lbs of MIC associated with $COCl_2$ and HCN.

Safety Devices and Violent Reaction.

The two safety devices for neutralising leaking MIC, *viz.*, the vent gas scrubber and the flare tower were non-functional. Moreover, the refrigeration unit connected to MIC storage tanks, which keeps the liquid at 0°C, had been closed down since June, 1984. As a result the gas was at 15°C. In a closed tank, the pressure due to reactions of MIC with H_2O or catalyst can build up to the point that safety valves will open, venting both MIC and phosgene ($COCl_2$) gas.

Misery, Panic and Death Drama. Between 12.30 and 1 a.m., people woke up coughing violently and with their eyes burning as if chilli powder had been sprayed into them. The deadly poisonous gas spread over 40 sq. km. seriously affecting the people up to a distance of 5 to 8 km. An estimated 500,000 people fled that night, most on foot.

In Jai Prakash Nagar every thing was so quiet-thousands lay dead on the roads and in homes. Corpses with distended bellies were beginning to rot. More than 2000 people lay dying in Hamidia hospital. By 1 a.m. on December 4, 1984 the hospital was crowded by 25,000 patients. The death drama continued for four days. More than 100,000 injured people were treated with limited medical care. Many people sat in silence, blinded and mained by unknown enemy. Within a week about

10,000 people died while more than one lakh people continue to suffer from various disorders. By December 13, 1984 about 1 lakh people left the city.

Neutralization Drama—Operation Faith.

The task of disposing off the balance MIC in the storage tanks was entrusted to the Director General of CSIR. It was decided to convert MIC into the final product, carbaryl. On December 16, the factory was started to restore faith among people. The operation ended on the seventh day and 24 tonnes of MIC had to be converted, 50% more than that was estimated.

The Aftermath. A medical survey held 100 days after the MIC exposure revealed that out of 250.000 people exposed, 65,000 were subjected to severe medical disability (respiratory, eye, neuromuscular, gastrointestinal, gynaecological symptoms) and 50,000 to mild disability. People suffering from breathlessness, digestion and sleeping problems are incapable of carrying on even light physical labour and unable to earn a living. Pregnant women were the worst victims.

Update about Bhopal Disaster.

Recent reports indicate that about 28,000 gas victims have died so far while an estimated 10 to 15 people are dying every month from exposure related ailments. More than 1,20,000 survivors are said to be still suffering from a variety of chronic diseases including respiratory tract problems, lung diseases, hypertension, anxiety, diminished vision, acute depression, muscular fatigue, recurrent fever, gynaecological disorders. The gas victims have not got proper medical care even after Rs. 250 crores have been spent for the purpose by the government. Thousands of people living in shanty towns near the factory complex are forced to drink toxic water because of the contamination of water table and soil. The State government has not provided clean drinking water to the gas victims although Rs 70 crores have been spent for environment upgradation. The **NGO Green peace** described the factory site as a **global toxic hot spot**. Finally, the Supreme Court directed the Government (July 19, 2004) to release Rs. 1,500 crore of Union Carbide money to the victims of gas leak.

Lesson. Now Bhopal holds out lessons that have to do with basic human concerns for safety, for standards and for good sense. If the lessons are lost, then it is possible that accidents such as this may be repeated in another factory, in another city, in another way.

• SMOG

Smog indicates air pollution in which atmospheric visibility is partially obscured by haze consisting of solid particulates and liquid aerosoals. The world smog is derived from an elision of smoke and fog, first coined by **H.A. Voeux** (1905). Smoky fog called **urban smog** (over industrial areas) happened in Meuse Valley of Belgium in 1930 which killed 600 people. mainly two types of smog have been recognised viz., London or sulphourous smog (classical smog) and Los Angeles or photochemical smog.

• LONDON (OR SULPHUROUS) SMOG

The most severe air pollution every occurred was due to sulphurous smog caused in London on December, 5, 1952, hence the name London smog was assigned. The mixture of smoke, fog and SO_2 that affected London so badly after the introduction of coal as a fuel, is chemically reducing mixture, so it is called reducing smog. Smog conditions provailed for five days at the cost of death of 4000

people. The cause of death were pneumonia, bronchitis and allied respiratory troubles. The peak SO_x concentration was 1.3 ppm and smoke 4 mg m^{-3}.

• QUESTIONS

1. What are the natural and man made pollutants that cause air pollution?
2. Enumerate various methods for the control of particulate and gaseous pollutants.
3. Discuss sources, adverse effects and control of water pollution.
4. How does soil pollution affect soil productivity? What measures can be taken to prevent soil pollution?
5. Explain various sources of marine pollution. How can you prevent pollution of our oceans?
6. Briefly describe the sources, effects and control of noise pollution.
7. Discuss various effects and control measures of thermal pollution.
8. Mention sources of nuclear pollution. What type of damage non-ionising radiations can cause?
9. Classify solid waste. How can the solid waste be managed?
10. How can you, as an individual, prevent environmental pollution? Why such an effort is important?
11. Why do earthquakes and seaquakes occur? Explain the case of 2004 Asian Tsunami.

SHORT ANSWER QUESTIONS

1. *How indoor air pollution originates?*
   Ans. Indoor air pollution originates from air conditioners, smoke, LPG gas cylinders, building materials (bricks, concrete, tiles which emit radon), carpets, insulating foams and adhesives used for installation.
2. *Name some equipments in air pollution control.*
   Ans. Packed towers, plate and spray towers, tray, columns and venturi scrubbers are used for air pollution control.
3. *Name some adsorbents or catalysts for SO_2 in flue gases.*
   Ans. Alkalised alumina, manganese oxide, Na (or K), SO_2, Cr, Cu, impregnated oxides supported on alumina are rated as superior catalysts.
4. *Give various types of scrubbers used to remove SO_2.*
   Ans. Spray towers, venturies, packed beds, turbulent-contact absorbers.
5. *State briefly modern modification of contact plant to reduce the emission of SO_2 in exit gases.*
   Ans. The modern Double Contact Double Absorption (DCDA) method provides higher plant efficiencies (99.5%) and SO_2 emission below 500 ppm. The gases from the converter (after 90% of SO_2 has been converted to SO_3) are interrupted and passed to an absorber to remove SO_3.
6. *State four sources of ground water pollution.*
   Ans. Shallow soakpits, seepage pits, refuse dumps, septic tanks, agricultural and industrial pollutants.
7. *Give the names of PCBs, 2, 4-D and 2,4, 5-T.*
   Ans. PCBs-Polychlorinated biphenyls. 2, 4-D is 2, 4-Dichlorophenoxy acetic acid. 2, 4, 5-T is 2, 4, 5-Trichlorophenoxy acetic acid.
8. *When water containing excessive nitrate is used for drinking, it causes methaemoglobinemia disease. How is this disease caused?*
   Ans. Nitrates in water are converted to nitrites by intestinal bacteria. Nitrites combine with the haemoglobin to form methaemoglobin which interferes with oxygen carrying capacity of the blood causing methaemoglobinemia or blue baby syndrome.

9. *What waste treatment methods would you suggest for purifying industrial effluents?*
Ans. Chemical coagulation and oxidation, adsorption, ion exchange, electrodialysis, reverse osmosis, ultra filtration.

10. *What are the objectives of water pollution control?*
Ans. Prevention of waste. Minimising the waste which cannot be prevented. Rendering harmless waste in the environment.

11. *How water pollution can be controlled from point sources and non-point sources?*
Ans. Water pollution can be reduced from **point sources** by legislation. Waste waters should be treated by primary and secondary treatments to reduce BOD, COD, total solids, nitrates, phosphates, toxic metals, oil and grease etc. However, it is difficult to prevent water pollution from **non-point** sources due to absence of proper strategies.

Following measures may help in reducing water pollution.

- Judicious use of agrochemicals, pesticides and fertilizers may reduce surface run-off and leaching.
- Adopting integrated pest management to reduce reliance on pesticides.
- Using nitrogen fixing plants to supplement the use of fertilizers.
- Divert run-off of manure to fields to use this nutrient rich water.
- Separate drainage of sewage and rain water should be provided to prevent overflow of sewage and rain water.

12. *Where eutrophication was first studied?*
Ans. Eutrophication was first studied in lake located in north western Ontario. It occurred due to man's activities in lake Erie in USA.

13. *Explain technical devices used to control eutrophication.*
Ans. Several technical devices alongwith prevention of further inflow of effluents have been used to **control eutrophication**.

- The waste water must be treated before its discharge into water streams.
- Recycling of nutrients can be checked through harvest.
- Eutrophication can be minimized by removing nitrogen and phosphorus at the source, division of nutrient rich waters from the receiving bodies and dilution of these elements. In lake Tahoe in California and lake Washington in Seattle, total removal of sewage effluents produced marked reversal of eutrophication.
- Algal blooms should be removed upon their death and decomposition.
- Algal food web should be disrupted to stimulate bacterial multiplication.
- Algal growth can be controlled by limiting the dissolved nutrients. The most suitable, feasible and effective method involves the use of chemicals to precipitate additional phosphorus. Such precipitants include alum, lime, iron and sodium aluminate.
- Physico-chemical methods can be adopted to remove dissolved nutrients. For example, phosphorus can be removed by precipitation and nitrogen by nitrification or denitrification, electrodialysis, reverse osmosis and ion exchange methods.

14. *List the processes employed in tertiary treatment of domestic waste water.*
Ans. Methods employed are coagulation, precipitation, absorption, nitrogen stripping, phosphate removal, chlorination and desalination etc.

15. *How the chlorinated pesticides can be removed from the waste water?*
Ans. Styrene divinyl benzene copolymer can remove chlorinated pesticides by adsorption at the surface of water.

16. *Why anaerobic waste water treatment is preferred as compared to other processes?*
Ans. Because energy (biogas) is produced instead of waste products, cheaper than aerobic process in respect of treatment of high strength waste waters and relatively low cost technology in terms of equipments.

17. *What can farmers do to increase agricultural production without increasing land use?*

Ans.

- Less persistent and harmless pesticides can be used.
- Pest control may be achieved biologically.
- Biofertilizers like Azolla, Azobacter, legumes, neem based ecofriendly substitutes are more promising.

18. *How pesticides can be detoxified on the soil?*

Ans. Pesticides can be detoxified by adsorption and biodegradation.

19. *List the strategies to protect the soil profile from waste products.*

Ans. In the modern frame work of utilizing the waste to protect soil profile, a four prolonged strategy has been adopted.

(i) Minimizing the quantity of waste.

(ii) Collection, transport and disposal of waste in an environmentally sound manner.

(iii) Treatment of waste.

(iv) Recovery and recycling of waste.

20. *How biotechnology can be useful in oil pollution control?*

Ans. Dr. Anand Mohan Chakraborty synthesized an oil eating superbug by introducing plasmids from different strains into a single cell of P. Putida. These microbes were used for cleaning up an oil spill in water in Texas (USA).

21. *Name the fungus which can decompose toxic compounds.*

Ans. White rot fungus, **Phanerochaete chrysosporium**, when placed in nitrogen deficient medium, can degrade DDT, PCBs, dioxane, halogenated aromatic rings producing CO_2.

22. *What are biofertilizers?*

Ans. Biofertilizers are biologically active products or microbial inoculants of bacteria, algae and fungi which can bring about soil nutrient enrichment. These are either nitrogen fixing (*e.g.*, rhizobium, azobacter, azolla, blue green algae, azospirillium) or phosphate solubilising.

23. *List various types of noise.*

Ans. Environmental noise, system internal noise, thermal noise, shot noise, partition noise, induced grid noise, flicker noise and impulse noise.

24. *How can you measure noise?*

Ans. Noise is usually measured by sound pressure or sound intensity. The sound intensity is measured in decibel (dB), which is the tenth part of the longest unit Bel. One dB is equal to the faintest sound, a human ear can hear.

25. *What is meant by noise control criteria?*

Ans. With increasing noise levels, annoyance, interference with communication and hearing etc., damage can occur. Noise control criteria are prescribed to provide standards for judging the acceptability of noise under various conditions.

26. *List some equipments used for noise measurement.*

Ans. Sound level meter, cassette recorder, magnetic tape recorder, pen recorder, noise average meters, noise analyser, noise limit indicator, vibration meters.

27. *How does nuclear pollution differs from air, water or soil pollution?*

Ans. Nuclear pollution is a physical type of environmental pollution which differs from other types of pollution in the respect that it not only affects the individual critically, but also brings physiological changes in the subsequent generations. The adverse effects due to pesticides, fertilizers, drugs, plastics etc. are mainly on the environment while nuclear pollutants directly or indirectly hit the target man.

28. *How Cs-137 contamination in soil can be rectified?*

Ans. Vermiculite, a neutral clay, binds Cs-137 in the soil to prevent the spread of radioactivity.

29. *How are the solid wastes classified?*

Ans. Solid wastes are classified into domestic, municipal, ndustrial, agricultural, electronic and biomedical wastes.

30. *What are the major considerations of management of solid waste?*

Ans. Waste separation for recycling, reuse, energy recovery, economic growth, public health and environmental protection.

31. *Why separation of wastes at source is receiving more attention?*

Ans. Because of increasing urbanisation, dwindling land fill capacity, economic incentives, improving markets for reclaimed materials and environmental concerns.

32. *When the Autothermic incineration of dewatered sludge is used?*

Ans. Autothermic incineration (conducting the process of thermal drying and incineration without additional consumption of fuel) is extremely useful when toxic substances in the sludge prevents its use as a fertilizer or in a land fill.

33. *Mention advantages and disadvantages of incineration.*

Ans. Advantages. Volume of waste is reduced to more manageable levels. Reduces land requirement. Residue after incineration is free from any degradable materials.

Disadvantages. Incineration produces SO_2, flyash, HCl, dioxins, furans and organic acids. Also operation cost is very high.

34. *List some methods of sludge disposal to prevent soil pollution.*

Ans.

- Disposal of sludge on lands.
- Drying on beds of earth, using press filters and vacuum filters.
- Extended or dispersed air processes, Simplex process, Aeration rotor process, Aerobic treatment, Dumping, Lagooning, Incineration and Swedish INKA process.

35. *What is meant by waste reuse and waste recycling?*

Ans. Transfer of the waste **as it is** without reprocessing to another facility is known as **waste reuse** or waste exchange. When a transfer of waste **as it is not** possible, reprocessing the waste for material recovery is known as **recycling**. That is, waste must first be treated before it can be used in a manufacturing process.

36. *Express hurricanes and teletsunami.*

Ans. Hurricanes are cyclonic storms with heavy rains and wind speed exceeding 120 km/hr. A tsunami which causes damage far away from its source is called teletsunami, produced by vertical motion of the sea bed rather than by horizontal motion.

37. *State the recent tsunami.*

Ans. The most devastating undersea earthquake (tsunami) measuring 9 on Richter scale has occurred in Japan on March 11, 2011. This seaquake inundated coastal communities, caused explosion in Phukushima Daichi nuclear reactor and the hazardous radiation leakage upto Tokyo and Russia.

MULTIPLE CHOICE QUESTIONS

1. Life saving gas in the atmosphere is

(a) Ozone in the stratosphere
(b) Water vapour in the troposphere
(c) Oxygen charged in the mesosphere
(d) Nitric oxide in the ionosphere

2. Sinks of atmospheric gases are

(a) Ocean surface
(b) Soil
(c) Vegetation
(d) All

3. Asphyxiation is caused by
   (a) NO_x (b) $HCN, COCl_2$
   (c) $CHCl_3$ (d) AsH_3
4. Pollutants emitted by jet planes are
   (a) Aerosol (b) Smoke
   (c) Smog (d) Fog
5. The world's strictest provision for the control of air and water pollution is in
   (a) China (b) India
   (c) Japan (d) USA
6. The killer in Bhopal disaster was
   (a) Carbaryl (b) Methyl isocyanate
   (c) Aldrin (d) Accidental fire
7. The symptoms of polluted water are
   (a) No external matter on the surface
   (b) Foul smell, bad taste, oil and grease on the surface
   (c) No change in physical appearance
   (d) Less density
8. Turbidity in water may be checked by coagulant such as
   (a) Ferric chloride (b) Ferric sulphate
   (c) Ferric alum (d) All
9. Disease caused by eating fish contaminated with methyl mercury is
   (a) Minamata disease (b) Hashimoto disease
   (c) Bright disease (d) Osteosclerosis
10. Treatment for drinking water supply requires
    (a) Sedimentation (b) Electrodialysis
    (c) Disinfection by chlorination (d) Filtration through sand bed
11. The world's fifth most devastated undersea earthquake (Tsunami) that strucked Indonesia, Sri Lanka and India was occurred on
    (a) December 26, 2004 (b) January 26, 2005
    (c) December 15, 2004 (d) January 15, 2005
12. Profuse growth of aquatic vegetation that reduces the dissolved oxygen content is called
    (a) Eutrophication (b) Algal bloom
    (c) Both (a) and (b) (d) Fermentation
13. Chemical substances indicative of water pollution are
    (a) Dissolved oxygen in water
    (b) Biological oxygen demand (BOD) in waste water
    (c) Chemical oxygen demand (COD) in water
    (d) All
14. Which among the following are more resistant to undergo decomposition in soil?
    (a) Carbohydrates (b) Tannins and lignins
    (c) Proteins (d) Lipids
15. Maximum permissible noise level for residential areas near road traffic is
    (a) 70 dB (b) 85 dB (c) 100 dB (d) 120 dB

16. Equipments used for noise measurement is/are
    (a) Cassette recorder (b) Pen recorder
    (c) Sound level meter (d) All
17. Solid waste management is best conducted by
    (a) Incineration (b) Sanitary land fill
    (c) Dumping into sea (d) Vacuum press filter
18. The recent most radio resistant genetically engineered bacterium to consume ionic mercury and toluene from nuclear waste is
    (a) Deinococcus radiodurans (b) Ophiostoma
    (c) Rhodotorula (d) Plasmid
19. Thermal power plants mainly produce
    (a) CO (b) Flyash
    (c) NO_x (d) $CaSO_4$
20. The biggest nuclear hazard comes from
    (a) X-rays (b) Cosmic rays
    (c) Microwaves (d) Alpha rays

FILL IN THE BLANKS

1. The ..... pollutants are emitted directly from the point source.
2. ..... forms the highest proportion in the vehicular exhaust.
3. The most important indoor air pollutant is ..... gas.
4. Minamata disease occurred due to consumption of ..... contaminated fish.
5. Cadmium has caused the disease ..... in Japan.
6. ..... when present in excess in drinking water causes blue baby syndrome.
7. Power plants utilize only ..... of the energy provided by fossil fuels for their operations.
8. Sound frequency is expressed in ..... .
9. The world's worst industrial accident occurred in Bhopal in 1984 due to the leakage of .....
10. Earthquake generated water waves are called ..... .

TRUE OR FALSE

1. Sulphur dioxide causes constriction of respiratory passage.
2. Sound can propagate without any medium.
3. Ground water is more prone to contamination due to soil mantle.
4. Rocket engine causes 180 dB of noise.
5. The saturation value of DO varies from 8 to 15 mg/L.
6. Solid wastes degraded by micro-organism are called non-biodegradable wastes.
7. The 2004 Asian Tsunami is also known as Boxing day tsunami.
8. The severity of an earthquake is measured by its magnitude on Richter scale.
9. Water and vegetation do not influence land slides.
10. Cyclones are recurring phenomenon in the tropical coastal regions.

ANSWERS

Multiple Choice Questions.

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

Fill in the Blanks.

1. Primary
2. CO
3. Radon
4. Methyl mercury
5. Itai itai
6. Nitrate
7. 1/3
8. Hertz
9. Methyl isocyanate
10. Tsunamis

True or False

1. True
2. False
3. False
4. True
5. True
6. False
7. True
8. True
9. False
10. True

UNIT

4

NATURAL RESOURCE MANAGEMENT AND BIODIVERSITY CONSERVATION

STRUCTURE

• INTRODUCTION

Natural resources are the life support materials or reserves which living organisms can take from nature for the sustenance of their life. For a sustainable development, conservation and management of natural resources (like water, air, soil, minerals, coal, forests, crops, wetlands, wildlife etc.) is extremely essential. With the phenomenal rise in human population, these resources are being heavily exploited. No doubt, the total global production is nearly enough to match the human demand for energy and materials if we judiciously distribute the resources available to us. But looking towards future scenario, the situation appears pretty grim due to degradation of natural ecosystems, deterioration of fertile soils, industrial proliferation, urbanisation and environmental pollution.

Natural resources are the raw materials obtained or derived from nature. A natural resource can be biotic or abiotic. **Biotic resources** can be derived directly or indirectly from photosynthetic activity of plants. Food stuff, fruits, milk, wood, fibre, fish, meat etc. are termed as biotic resources. Coal, oil and natural gas are also referred to as biotic resources. **Abiotic resources** include minerals, fresh water, salts, chemicals etc. since biological activity is not involved in their formation. Natural resources are of two kinds, that is, renewable and non-renewable.

Renewable and Non-renewable Resources.

Renewable resources are inexhaustive and mostly biological in nature. These resources can be recycled, regenerated or harvested continuously through a

sustained proper planning and management. Examples are solar energy, wind energy, hydropower and forests etc.

Non-renewable resources are exhaustive and physical in nature which can not be regenerated. Examples constitute fossil fuels such as coal, oil, petroleum, natural gas, minerals etc. Even renewable resources are endangered and liable to extinct if these are exploited recklessly, e.g., forests.

Major-natural resources are :

- Forest resources
- Food resources
- Water resources
- Energy resources
- Mineral resources
- Land resources

• FOREST RESOURCES

A plant community predominantly of trees and other vegetation usually with a closed canopy is called **forest** derived from Latin word Foris meaning **out of door**. Today forest may be regarded as any land managed for the diverse purpose of forestry, whether covered with trees, shrubs, climbers, lianes or not. About 33% of the world's land area is under forest cover. CIS accounts for about 20% of the world's forests, Brazil for 15%, Canada and USA for 6%. Covering the earth like a green blanket, these forests not only produce innumerable material goods but also provide several environmental services which are essential for life.

USES OF FORESTS

1. Commercial uses. The forests of a country make a **natural asset** of immense value. They produce a large number of products of commercial as well as industrial importance. Some of such valued products are structural timber, charcoal, raw materials for the manufacture of paper, newsprint, panel products, bidi leaves, resins, gums, essential oils and a number of useful medicinal shrubs.

- **Bamboos** are tall, perennial, arborescent grasses characterized by woody stems, called culms. Bamboos are the poor man's timber, used as rafters, scaffolding, roofing, walling, flooring, matting, basketry. More than **100 species of bamboos** are found in the **Indian forests** and are suitable for making paper, rayon and canes etc. Bamboo wood is also used as ropes, cables of suspension bridge in forests, for furniture, umbrella handles and sports goods etc.
- **Babul bark** is an important tannin material. Gum and resin exuded from plants are used in textile industry, cosmetics, cigar and food industry etc. The most important resin is obtained by tapping the **chir pine.** It is a flourishing forest industry.

2. Ecological uses. Most of the ecologically useful plants are in the form of herbs, shrubs, climbers and grasses. Tropical forests are considered as the **lungs of the earth** and have aptly been called as the life support system. They are the **treasure houses of food, medicines and commerce.** These forests harbour some very primitive species of plants and animals and provide the most stable environment for life and land. Between 1999 and 2009, about 350 million hectares of tropical forests (equivalent to 4 times the size of France) have been converted to other uses.

3. Regulation of climate. Rain forests, the most primitive ecosystems, are universally recognised for regulating the global climate, rainfall and the consequent productivity of land and water.

4. Reducing global warming. The forest canopy absorbs CO_2 during photosynthesis and acts as a sink for green house gases.

5. Soil conservation. A properly stocked forest guard against soil erosion, damage of water sheds, floods and sedimentation.

6. Regulation of hydrological cycle. Forested watersheds act like giant sponges, absorb rain water, increase humidity by transpiration and regulate hydrological cycle.

7. Medicinal value. Most of the **medicinal plants** are found in the under brush strata of the forest. They contain chemicals such as alkaloids, glycosides, terpenoids, lignans, fatty acids, resins, tannins, gums and many other substances which have specific effects on the human body. For example, Tinospora cordifolia, Vitex trifolia, Serpentina, Eucalyptus, rusa grass, khus, camphor and sandal wood are used in medicines. Quinine, a malaria drug, is obtained from the bark of Cinchona.

8. Oils. Essential oils, obtained from a variety of forest plants, are used in the manufacture of soaps, cosmetics, pharmaceuticals, confectionery and tobacco flavouring etc.

9. Food products. Vegetative shrubs, herbs, climbers, ferns, mosses are derived from trees and consist of flowers, fruits, leaves, bark, stem or root. Several forest fruits, flowers and even leaves and roots are eaten. Examples are **bel, ber, phalsa, jamun, khirni and tendu.** The parts of some plants are used as vegetables and for making pickles. Examples are amla, anar, imli, karaunda, kokam, kachnar etc. Kalazira is the seed of carum carvi and is used as a spice. **Shahtoot** fruit is eaten or made into a sharbat. Tendu leaves are used as wrappers of tabacco to make bidis.

10. Desert vegetation. India is gifted with cold desert vegetation of Tibet Plateau. It has been estimated that more than 15000 known **floral species** are found in India. The North-East region, comprising of Assam, Tripura, Meghalaya etc. is the richest zone. There are more than 6700 **endemic species** largely found in Himalayas and Western Ghats of Peninsular India.

11. Shelter for tribal people. The forests play an important role in the life of tribal people living in close proximity of forests because latter provide them food, shelter, timber, wood fuel, fruits, meat, medicines, hides, skins and other products of their daily and commercial uses. Forests also give shelter to diverse species of plants, wildlife and micro-organisms.

12. Pollution moderators. Forests absorb many toxic gases and can help in keeping the air pure. They also absorb noise and thus help in preventing air and noise pollution.

13. Aesthetic value. Forests also have a great aesthetic value. All people appreciate the natural beauty and tranquility of forests.

OVER EXPLOITATION OF FORESTS.

Exploitation of vast potential of forests may be due to following causes.

1. Commercial Demand. Forests contribute substantially to the national economy. The international timber trade alone is worth over US $ 40 billion per year. But the commercial demand for pines, teak, sal and conifers have turned the productive forest wealth into near desert.

2. Raw Materials for Industrial Use. Wood, timber, wooden crates for making furniture, railway sleepers and pulp for paper industry have exerted

tremendous pressure on forests. Plywood is in great demand for packing tea in tea industry while fire tree wood (ten times more) is exploited for packing apples alone.

3. Development Projects. Mega Projects of the World Bank, construction of dams, hydroelectric projects, power stations, roads, highways, railways, open cast coal, lime stone mines have been instrumental for the massive destruction of forest cover. The tidal mangrove forests called **Sunderbans** have been stripped and the Southern Peninsula has turned to acacia scrub semidesert. The tropical deciduous forests of Vindhyan ranges of Mirzapur were replaced with a savannah ecobiome and near barren wasteland due to excessive exploitation.

4. Growing Food Demands. Forest wealth has been recklessly exploited by agricultural lands and settlements.

5. Fuel Requirements. Increasing demands for fuel wood by growing population in India has shooted up to 600 million tonnes in 2010. If the trend continues, time will come soon when the cost of fuel would be much higher than the cost of food.

ASSOCIATED PROBLEMS OF FORESTS.

- Over exploitation of forests is responsible for soil erosion, loss of wildlife and biodiversity, change in land scape, wind direction, floods, drought and global warming.
- Deforestation upsets the delicate balance of nutrients, gases and symbiotic relationship between man and plants.
- Tropical forests, considered as the **lungs of the earth**, are under a virtual death sentence owing to burgeoning population density. Merciless clearing of plant species **(genetic erosion)** at the rate of 8 million hectares per year have resulted in tremendous loss of vast reservoir of genetic diversity.
- **Hydrological** cycle gets affected thereby influencing rain fall.
- **Horticulture** has contributed to social destabilisation, eco-destruction and massive deforestation. The **snow line** of Himalayas is continuously receding, an extremely serious phenomenon with far reaching consequences.

Hot Beds of Extincting Forests. Some extincting tropical forests are: Madagascar, Western Eucador, Colombian, Choco, Western Amazonia, Northern Borneo, Eastern Himalayas, Peninsular Malaysia, Philippines and New Caledonia.

DEFORESTATION.

Destruction of biotic potential of land leads to deforestation, *i.e.*, forest destruction. The total forest area of the world was estimated to be 7000 million hectares in 1900 which fell down to 2100 million hectares by 2010. This process of **deforestation** is a serious threat to economy, quality of life and future of the environment in our country.

Some important forest figures for India are illustrated below.

Indian Forest Statistics.		
• Total forest area	:	67,701,000 ha
• Percent of land area	:	22.8%
• Deforestation rates		
Total forest loss (since 1900)	:	3,762,000 ha
Annual forest loss (2000–2005)	:	29,400 ha
• Break down of forest area		

Natural	:	32,943,000 ha
Semi-natural	:	31,532,000 ha
Production plantation	:	1,053,000 ha
Plantations (2005)	:	3,226,000 ha
• Forest classification		
Public forest	:	98.4%
Private forest	:	1.6%
• Forest use		
Production	:	21.2%
Protection	:	14.8%
Conservation	:	21.7%
Multiple purposes	:	42.4%

Source. MOEF (Annual Report 2005–06)

- **Note that** we are still far behind the target of achieving 33% forest area as per National Forest Policy. Despite increasing awareness, deforestation rates continue to increase.
- Each day about 32300 ha of forest disappear and another 32300 ha of forest suffers degradation.
- During 2005–2010, the tropical deforestation rate has increased by 9.5% as compared to 1995's deforestation rates.
- Primary forests has lost by 25%.
- Further, forests are being replaced by plantations with much less biodiversity.

Major Causes of Deforestation.

- **Rapid explosion** of human and livestock population.
- **Over grazing** by cattles, indiscriminate felling of trees and over exploitation of land resources.
- Construction of dams destroy thousands of square kilometres of **tropical forests.** The process of filling the reservoirs may drown large tracks of forests, displace people and kill wild life.
- Although dams are intended to provide inexpensive electricity, many of them are economic failures because of lack of environmental planning. Erosion of water shed fills reservoirs with silt and reduces the ultimate output and useful life of dams.
- **Proliferation of industries,** quarrying, irrigation and expansion of agricultural lands for farming to meet the growing food demands.

• CASE STUDIES

Desertification in Hilly Regions of Himalayas

Deforestation in Himalayas, involving clearance of natural forests and plantation of monocultures like Pinus roxburghi and Eucalyptus camadulensis have upset the ecosystem by changing edaphic (soil), physical and biological properties. So nutrient cycling has become poor, original rich germ plasm is lost and the area is invaded by exotic weeds. Consequently, the soil is losing its fertility. The entire west Khasi hill districts of Meghalaya in North-east Himalayas, Ladakh and parts of Kumaon and Garhwal are now facing the serious problems of Desertification.

Waning Rainfall in Nilgiri Mountains.

The sub normal rainfall during 1965-84 at Ooty (Udhagamandalam) in Nilgiri mountains has been found to be closely associated with decling forest cover in this region. When the Nilgiri mountains had luxuriant forest cover, annual rainfall was much higher.

Disappearing Tea Gardens in Chhota Nagpur.

Chhota Nagpur had a good forested areas towards the turn of the century and used to receive frequent afternoon showers favouring tea plantations. Following the destruction of forests, rainfall declined to such an extent that tea-gardens disappeared from the region.

• CHIPKO MOVEMENT (WILDERNESS ETHIC)

Perhaps the first forest movement against indiscriminate felling of trees was fought in India in 1730 by a Bishnoi woman. The leader of this movement, **Amrita Devi** with her 363 followers, resisted the felling of Khejori trees in **Jodhpur**. The contractors axed the trees to death. Later on, the ruler of Jodhpur banned tree felling. Chipko (to hug or stick to) movement was first launched by a tribal woman in Tehri Garhwal district of Uttarakhand in 1972. It came into lime light in 1973 in Gopeshwar in Chamoli district. It gained momentum in February 1978, when the women of Advani village embraced the trees, faced police firing and later courted arrest. This movement continued under the leadership of **Sunder Lal Bahuguna** and **Chandi Prasad Bhatt** against massive felling of trees by timber contractors in Uttarakhand hills (UP).

This novel campaign of saving hill forest and greenery soon spread all along the hill region (Salkane forest in Sirsi district, Aravali of Rajasthan) and to Karnataka where it was named Appiko. The **first Appiko** was sparked off on September 8, 1983 with the objective to protect the trees and to conserve the forest resources. In the course of time, the Chipko movement crossed geographical boundaries and observed as **Chipko Day** at New York, USA on April 29, 1983. Children assembled and hugged a big tree in Union Square Park.

The plantation of **five Fs–Food, fodder, fuel, fibre and fertilizer trees** will generate a self renewing decentralised and economic prosperity to the nation.

• MAJOR ACTIVITIES IN FORESTS

Timber Extraction.

Logging for valuable timber, such as teak, sal and mahogany not only destroys large trees per hectare but also uproot the dozen more trees since they are strongly interlocked with each other by vines etc. Road construction for making approach to the trees causes further damage to the forests. Wood extraction in 2009 was estimated to be 1.9 m^3 in India.

Mining.

Mining is done to extract minerals or fossil fuels from shallow deposits by **surface mining** or from deep deposits by **sub-surface mining.** Currently, more than 80,000 hectare of land in India is under the stress of mining activities. Mining destroys vegetation along with underlying soil mantle and overlying rock masses. This results in defacing the topography and destruction of the landscape in area.

- Indiscriminate mining in forests of Goa since 1991 has lost more than 50,000 hectare of forest land.
- Coal mining in Jharia, Singrauli and Raniganj have caused extensive deforestation in Jharkhand.

- Mining of radioactive minerals in Kerala, Tamil Nadu and Karnataka is also posing the threat of deforestation.
- Mining of magnesite and soap stones have destroyed 14 hectare of forest in the hill slopes at Khirakot, Kosi valley and Almora.
- Rich forests of Western Ghats are declining due to mining projects for excavation of copper, chromite, magnetite and bauxite.
- Large scale deforestation (over 40 km) has been reported in Mussorie and Dehradun valley due to indiscriminate mining of various minerals. The forested area has declined upto 33% and increase in non-forest area has resulted in unstable zones leading to landslides.

• DAMS AND THEIR EFFECTS ON FORESTS AND PEOPLE

Big dams like Bhakra-Nangal, Heerakund, Nagarjuna Sagar and Damodar etc. have multipurpose uses and have been referred to as **Temples of modern India.** India has about 1850 major dams, the maximum being in the state of Maharashtra (650), followed by Gujarat (more than 250) and Madhya Pradesh (130). The highest one is **Tehri dam** on river Bhagirathi in Uttarakhand and the largest in terms of capacity is Bhakra dam on river Satluj in Himachal Pradesh.

Large dams have been in sharp focus of various environmentalists all over the world which is mainly because of ecological disasters including deforestation and socio-economic problems related to tribal or native people associated with them. **The Silent Valley** hydroelectric project was one of the first such projects situated in the tropical rain forest area of Western Ghats that attracted much concern of the people.

The crusade against deforestation and ecological damage caused due to **Tehri dam** was led by Sunder Lal Bahuguna, the leader of Chipko Movement. Likewise, problems associated with **Sardar Sarovar dam** have been raised by environmental activists Medha Patekar joined by Arundhati Roy and Baba Amte.

- Dams are responsible for large scale devastation of forests and disruption of natural ecological balance of the region.
- Floods, droughts and landslides become more prevalent in such areas.
- Dams submerge forest, displace local people, cause water logging and siltation.
- Forests are the repositories of invaluable gifts of nature in the form of biodiversity.
- Plant species could be having marvelous economic or medicinal value. This store house of species which have evolved over millions of years get lost due to deforestation in a single stroke.

Sardar Sarovar Dam (Uprooted Forests and Tribals)—A Case Study.

Sardar Sarovar dam is situated on river Narmada and is spread over three states of Maharashtra, Madhya Pradesh and Gujarat. Although the project is aimed at providing electricity, irrigation water and drinking water to the three states but the environmental impacts of the project have raised challenging questions. A total of 1,44,731 ha of land (including 56,550 ha of forest land) and 575 villages are submerged by the Narmada dam. Submergence of about 40,000 ha of forest under Narmada Sagar, 13,800 ha under Sardar Sarovar and 2500 ha under Omkareshwar would further create pressure on remaining forest areas in adjoining regions. Many of the wildlife species found in these areas are listed in schedule I and II of Wildlife Protection Act, 1972. Thus massive loss of wildlife is apprehended due to the devastation of forest under the project.

As per the estimates of the Institute of Urban Affairs, New Delhi, the Narmada Valley project will lead to eventual displacement of about one million people. This is probably the largest rehabilitation issue ever encountered as per the **World Bank.** Uprooting the tribals and forced shifting in far-flung areas disturb their normal living. Besides serious economic deprivation, the displacement will affect tribal's culture, their beliefs, festivals, myths and rituals, all closely associated with the forests, hills and streams. Most of these tribals belong to poor, unprivileged schedule castes and tribes. The displaced persons have to face hardship and distress for the sake of development and prosperity of a larger section of the society. It is therefore the duty of the project proponents and government to provide proper rehabilitation to the displaced tribals.

FOREST CONSERVATION.

The **National Forest Policy** of India (1988) recommended that one-third (33%) of our land should be under forest cover. But today, the forest cover has reduced to merely 12%. Per capita forest area available in India is 0.06 hectare as against 0.64 hectare of the world's per capita forest area. We have almost reached a critical state which must be remedied before it is too late for our own survival.

The potential of forests must be tapped and nurtured but we must stop over-exploitation. A recent **World Bank** study (2004), showed that if we unlock the opportunities for Indians from its forests, there will be a boost in economy from 222 million US dollars to 2 billion US dollars in the next 15 years. In India, **Joint Forest Management** has come up as an innovative approach involving community participation, so that rural economy is strengthened and forest resources are conserved.

Some Conservation Strategies.

(i) Conservation of Reserve Forests. Reserve forests include National Parks, Sanctuaries, Biosphere Reserves and the areas where major water resources are located, *viz.*, the Himalayas, Western and Eastern Ghats. These must be protected and no commercial exploitation be allowed in these areas.

(ii) Production Forestry. These are forests on the plains and their productivity can be enhanced by proper management. Generally, fast growing trees (Eucalyptus, Acacia) are grown using modern techniques. Production or commercial forestry is intended entirely for commercial purposes to meet the needs of the forest based industry. Grazing lands, fallow lands not used for agriculture can be used for raising such plantations.

(iii) Social Forestry. Social forestry is based on public and common land to produce firewood, fodder, fruit and small timber for rural community. The aim is to reduce pressure on natural forests for these requirements.

(iv) Agro Forestry. Same land is used for farming and forestry by **taungya** (growing crops between rows of trees) and **jhum** (shifting crop and forest cultivation) techniques.

(v) Urban Forestry. It aims at growing ornamental and fruit trees along roads, parks or vacant lands.

• WATER RESOURCES

The chief sources of water are rain water, sea water, ground and surface water. The **World's total quantum** of water is 140×10^{16} m^3.

Sea Water.

About 97% of earth's water supply is in the ocean which is unfit for human consumption and other uses due to high salt content. Of the remaining 3%, 2.3% is

locked in the polar ice caps and hence out of bounds. The balance 0.7% is available as fresh water. If all the **sea beds** could be filled up and brought at the level of the earth surface, then the entire water in the seas would cover the earth's surface and make it **2.5 km deep water** mass.

Ground Water.

Ground water, a **gift of nature**, is about 210×10^9 m^3 (0.66%) including recharge through infiltration, seepage and evapotranspiration. Out of this nearly one-third is extracted for irrigation, industrial and domestic use, while most of the water is regenerated into rivers. Of the fresh water below the surface about 90% satisfies the description of ground water that is, water which occurs below the water table. About 2% water occurs as soil moisture in the unsaturated zone above the water table and is essential for plant growth.

The major portion of water (about 165×10^{10} m^3) which goes to earth crust is retained as soil moisture. Only 500×10^9 m^3 percolate down to the ground water deposits. About 120×10^9 m^3 of water applied to agricultural fields moves down to ground water table and 50×10^9 m^3 of surface flow also end up as ground water. Thus a total of 670×10^9 m^3 fresh water enters the ground annually.

Surface Water.

We have a very limited stock of usable water that is, 0·03% of the mass balance. The 115×10^{10} m^3 of surface water is enlarged by the addition of about 450×10^9 m^3 of fresh water from ground water flow, 200×10^9 m^3 from surface flow and 50×10^9 m^3 as run off from irrigated areas. The surface loses almost 50×10^9 m^3 of its water which percolates down to ground water deposits. The total surface flow per year is 185×10^{10} m^3 which are distributed among river basins.

Rain Water.

In India, the annual rain fall is about 400×10^{10} m^2. Out of this, 70×10^{10} m^2 of water evaporates immediately, 115×10^{10} m^2 runs off into surface water bodies and the remaining percolates into the soil. The **hydrological cycle** in nature is more or less balanced in terms of charge (cloud formation) and discharge (rain fall).

• WATER QUALITY

It is essential to enforce water quality standards to specify water suitability for drinking, irrigation, industry, public health and environmental safety purposes. All developed countries strictly conform to water quality standards. The United States Public Health (USPH) has laid down following standards for drinking water.

Table 1. Water quality parameters (Domestic water supplies) and USPH Standards.

Parameter	USPH Standards	Parameter	USPH Standards
pH	6.0–8.5	Chloride	250.0
Dissolved oxygen	4.0–6.0	Sulphate	250.0
Total dissolved solids	500.0	Cyanide	0.05
Suspended solids	5.0	Nitrate + nitrite	10.0
Calcium	100.0	Iron	0.3

Magnesium	30.0	Lead	0.05
Mercury	0.002	Arsenic	0.05
Chromium VI	0.05	Phenol	0.001
COD	4.0	Detergents	0.1

Note. All parameters except pH are in ppm or mg/L.

The quality parameters for surface water (rivers, lakes, ponds) are 4 to 5 times higher than the above values for drinking water. The delicate balance existing between the ratio of available and exploitable water resources and sustaining their quality should be maintained to support the life systems on earth. Water for domestic purposes should be free from :

- Materials which impart colour, taste or turbidity, *e.g.*, oils, grease, phenols etc.
- Substances which may settle to form objectionable deposits or float on the surface as debris, oils and scum.
- Toxic substances including radionuclides, physiologically harmful to man or other aquatic life.

• WATER USE AND OVER-EXPLOITATION

Water, a vital natural resource and precious commodity, is essential for multiplicity of purposes. Human beings depend on water for almost every developmental activity. Out of 30% stream flow, **water consumed by man is :** 8% for irrigation, 2% for domestic use, 4% for industrial consumption, 12% for electrical utilities, 4% for transportation and waste disposal. Water shapes the earth's surface and regulates our climate. Water use by man is of two types :

(i) Water withdrawal that is, using ground water or surface water. But with the rapid growth of population, many countries are now using **desalinated sea water** as a potential source of supply of potable water in scarcity hit regions. Desalination may be accomplished by processes such as distillation, freezing, electrodialysis and reverse osmosis.

(ii) Water consumption that is, water which is taken up but not returned for reuse. Globally, only 60% of the water withdrawn is consumed due to loss through evaporation.

Water Consumption in Major Sectors.

Irrigation. Agriculture sector is the major consumer (93%) of water in India (Table 2). While in a country like Kuwait, which is water poor, only 4% is used for watering the crops. On a global average, 70% of water withdrawn is used for irrigation.

Table 2. Estimates of water requirements (in cubic kilometres) in India.

Water needed for	1974	2000	2025
Irrigation	350.0	630.0	770.0
Thermal power generation	11.0	60.0	160.0
Industries	5.5	30.0	120.0
Domestic needs	8.8	26.6	39.0
Livestock in management	4.7	7.4	11.0
Total	380.0	754.0	1100.0

Industries. About 25% of water on global average is used in industry which again varies from 70% in European countries to 5% in less developed countries.

Power generation. In India, power generation sector will require about 15 times more water by 2012 than it was in 1974.

Domestic water needs. Per capita consumption of water shows wide variations. In USA, an average family of 4 consumes more than 1000 m^3 of water per year which is many times more than that in most developing countries. With growing population, the demand for high quality fresh water is steadily increasing but its availability is dwindling because of misuse, wastage and pollution.

World Health Organisation. Current estimates show that water consumption will have to be cut by 50% by 2025 if nations fail to address imbalances in global water supply and demand.

Effects of Overuse of Ground Water.

1. Lowering of water table. Excessive use of ground water for drinking, irrigation and domestic purposes have resulted in rapid depletion of ground water table leading to drying of wells and sharp decline in future agricultural production.

2. Ground subsidence. When ground water withdrawal is more than its recharge rate, the sediments in the aquifers become compacted causing ground subsidence. It results in sinking of overlying land surface which may damage buildings, causes fracture in pipes, reverses the flow of sewers and canals and tidal flooding.

3. Water logging. Excessive irrigation with brackish water raises the water table leading to water logging and salinity problems.

• FLOODS

Flood refers to a situation when the limits of river banks, *i.e.*, the natural level fails to contain the entire flow of the river water and water inundates the land along with the river channel. Flash floods are highly localised and caused by **cloud bursts** during the monsoon.

Causes of Floods.

1. Natural Causes.

- *The natural factors which cause river floods are prolonged high intensity monsoonal rain fall. In the snow fed rivers of north India, excessive snow-melt could swell up the streams causing them to flood.*
- *The natural causes of flood also include the cyclones, volcanic eruptions, earthquakes, landslides, flash floods and the resultant devastation. Heavy spell of rainfall in the arid and semi arid regions, where the rainfall is generally scant, low and infrequent, causes flash floods in rivers. Such rivers are unable to accommodate enormous volume of water due to poor natural drainage systems. For example, unprecedented rainstorms in Jaipur city (Rajasthan), India in 1981 caused flash floods and raised the level to 836·4 mm in rivers.*

2. Anthropogenic Causes.

- *Man-made activities such as indiscriminate deforestation, building construction, urbanization, industrialization, channel manipulation through diversion of river course, reservoirs, construction of bridges and roads, etc. cause disastrous floods in rivers.*

- *Accumulation of huge wastes, filling of urban drains, sedimentation, inadequate drainage system in irrigated lands, gradual encroachment of human settlements near the channels are the significant factors causing river floods.*
- *The riverine cities like Kanpur, Varanasi and Allahabad in India, located along the mighty Ganga river are the burning examples of ecological degradation caused by recurrent floods of the Ganga river.*

Main Flood Zones in India.

- Rivers of Himalayas comprising the Ganga, Brahmaputra and their tributaries.
- The north western river basins of Ravi, Jhelum, Chenab, Satluj and Beas.
- The central India and Peninsula river basins consisting of Yamuna, Godavari, Cavery, Tapti, Narmada, Chambal, Krishna and Mahanadi.

Areas located around these rivers particularly North Bihar, eastern U.P., Delhi, Punjab, Haryana and north east Rajasthan account for 90% of the total flood damage.

Effects of Floods.

- Floods are among the most destructive phenomenon of nature. World-wide flood damage to agriculture, buildings, roads, bridges and public utilities account to billions of dollars every year along with the loss of precious human and animal lives.
- The maximum flood damage loss was estimated at Rs. 21 crores in 1951. It was Rs. 4060 crores in 1995 and Rs. 9000 crores in 2010.
- Sheet erosion of soil and sand casting occur due to flash floods. This sediment load in rivers causes their water level to rise disrupting the aquatic life.
- Flash floods generally revitalize the dead drainage system so that the streams become very active. The area cultivated in the beds of buried drainage system get inundated.
- People of Bangladesh are accustomed to moderate flooding during monsoon and they utilize the flood water for raising paddy. But severe floods like that in 1978, 1988, 1995 and 2010 resulting from excessive rains, Himalayan runoff and storms have very disastrous consequences causing massive deaths and damages. In September 2010, millions of people were drowned and died in several villages of Punjab, Haryana, Uttar Pradesh and Uttarakhand due to heavy rainfalls.

Flood Control Measures.

1. Flood Plain Zoning. Flood plain zoning aims at determining the locations and the extent of areas likely to be damaged by floods.

2. Flood-proofing Measures. These measures include location and construction of industries, public utilities, telephone exchange, electricity installations, railway stations, aerodromes and commercial centres above the observed flood levels so that they may remain unaffected in the event of flood.

3. Flood Risk Maps. It is possible to demarcate the zones for different flood frequencies with the help of data and maps. Maps can predict the areas liable to be affected at different water levels.

4. Flood forecasting and early warning to affected areas are among the most important and cost effective means to reduce the impact of floods. Today, satellites like IRS-IB and INSATs predict accurate flood forecasting.

Other Control Measures.

- Floods can be controlled by afforestation and by constructing dikes, revetments, embankments and artificial levees.
- Meander loops and bends in the highly sinous rivers can retard the quick disposal of water.
- Storage reservoirs can be used to control the flood. Such reservoirs were constructed on Miami river in the state of Ohio, USA.
- Flood diversion systems, flood walls, detention basins, watershed management, advance flood warning and emergency evacuation may reduce the flood magnitude.
- Net working of rivers is being proposed to deal with the problems of floods.

• DROUGHT

Drought is an insiduous phenomenon which creeps over an extensive area. Indian Meteorological Department (IMD) defined drought *as a situation when the mean annual rainfall is less than 75% of the normal rainfall and there is shortage of surface or ground water affecting plant life adversely.* Severe drought occurs when the deficiency of rainfall exceeds 50% of the normal rainfall for 21 days or more. Although rainfall is the main parameter for the determination of drought yet other drought indicators may be used which include evaporation, humidity, wind air temperature, solar radiation, soil moisture, stream flow and plant conditions. Drought thus indicates **dryness or want of water.**

There are about 80 countries in the world, lying in the arid and semi-arid regions that experience frequent spells of drought. Recently, the irrigation commissions has identified certain chronic drought areas as Rajasthan, Kutch, Gujarat and adjoining parts of Punjab, Haryana, west M.P. and west U.P.

Causes of Drought.

Drought is a meteorological phenomenon associated with natural El Nino and Southern Oscillation (ENSO), as well as anthropogenic causes like deforestation, overgrazing, mining and global warming etc. In India, extensive desertification has increased the vulnerability of larger parts of the country to drought. Errorneous and intensive cropping pattern and increased exploitation of scarce water resources through canal irrigation has converted drought prone areas into desertified ones. In Maharashtra, there has been no recovery from drought for the last 30 years due to over-exploitation of water by sugarcane crop which has high water demands.

Impact of Drought.

The most serious drought event occurred in 1982 showing full impact all around the globe. There were droughts in north-eastern **Brazil** (14 million people affected), north **China** (grain yield reduced to 10%), **India** (food production dropped by 4%), **Indonesia** (380 hunger, thirst and starvation deaths) and eastern **Australia** (disease and death).

In India, there have been 23 occasions when drought has occurred and rainfall deficiency was found to be 1.0 SD. Drought episodes in 1911, 1925, 1941, 1951, 1969, 1998, 2002, 2008 in India were so disastrous and catastrophic that they severely affected all types of life forms as follows.

- Acute shortage of drinking water.
- Loss of standing crops and sensitive species of plants.
- Scarcity of food, fodder and fuel.
- Migration of animals to other places.

- Adverse effects on agro based industries.
- Acute effects on hydel power generation.
- Increase in imports etc.

Control Measures.

There are some long term measures to ameliorate the severity of drought.

- Use of water from all sources, *i.e.*, rainfall, surface and underground water.
- Construction of tanks, ponds, reservoirs and wells to provide irrigation facilities.
- Lining of canals and distributories to minimise water losses.
- Introduction of mixed cropping that would optimise production and minimise the risks of crop failures.
- Introduction of water conservation schemes and dry farming techniques.
- Development of horticulture and pastures.
- **Social forestry and wasteland development** can prove quite effective to fight against drought, but it should be based on proper knowledge of ecological requirements and natural processes, otherwise it may even boomerang. The Kolar district of Karnataka is one of the leading districts in Social Forestry with World Bank Aid, but its all (11) talukas suffer from drought. It is because, they have planted Eucalyptus which is responsible for lowering down the water table due to their high transpiration rate. It is therefore, important to select the plantation depending upon the climate, soil texture and its water requirements. Afforestation can mitigate the problem of drought by increasing air moisture, precipitation and the rate of rain water infiltration.

A **Drought Prone Area Programme** (DPAP) was launched in 2008 in arid and semi-arid regions with poor natural resource endowments. The **aim** was to promote more productive dryland agriculture by better soil and moisture conservation, scientific use of water resources, afforestation, livestock development and to restore ecological balance.

• CONFLICTS OVER WATER

Indispensability of water and its unequal distribution in different countries has often led to inter-state or international disputes. Out of India's 18 major rivers, 17 are shared between different states. Issues related to sharing of river water have been largely affecting our farmers and puzzling governments. Some major water conflicts are discussed below.

1. Water Conflict in the Middle East. The shared water resources for Middle East countries are the three river basins, *viz.*, the **Jordan, the Tigris-Euphrates and the Nile.** Ethiopia controls 80% of Nile's flow and plans to increase it. Sudan is also trying to divert more water. This would badly affect Egypt, which has a thin strip of irrigated cropland along the river Nile. Likewise, there is a fierce battle among Jordan, Syria and Israel for the share of Jordan river water. **Turkey** has abundant water and plans to build 22 dams on Tigris-Euphrates for hydro electric power generation. But it would drastically reduce the flow of water to Syria and Iraq. Turkey also plans to transport and sell water to starved Saudi Arabia, Israel, Kuwait, Syria and Jordan. The next war among Middle East countries would be fought over water and not oil.

2. The Cauvery Water Dispute. The Cauvery river water is a matter of conflict between Tamil Nadu and Karnataka. Tamil Nadu, occupying the downstream region of the river wants water-use regulated in the upstream,

whereas Karnataka refuses to do so and claims its primacy over the river as upstream user. Both the states have increasing demands of river water for industry and agriculture. Water consumption is more in Tamil Nadu than Karnataka where the catchment area is more rocky. On June 2, 1990, the **Cauvery Water Dispute Tribunal** was set up which directed Karnataka to ensure that 205 TMCF of water was made available in Tamil Nadu's **Mettur dam** every year, till a settlement was made.

In 1991–92, there was no dispute due to good monsoon but in 1995, the situation turned into a crisis due to delayed rains. The **complex cropping pattern in Cauvery basin** like Sambra paddy in winter, Kurvai paddy in summer and some cash crops required intensive water, thus aggravating the water crisis. Proper selection of crop varieties, optimum use of water, rational sharing patterns and pricing of water are suggested as the remedial measures to solve the dispute.

3. The Satluj-Yamuna Link (SYL) Canal Dispute. The sharing of Ravi-Beas waters and SYL issue between Punjab and Haryana is a case of dispute between these two states. The Supreme Court on January 15, 2002 directed Punjab to complete the work of SYL. But till date neither the SYL work has been completed nor the conflict over sharing of Ravi-Beas water is resolved. The conflict is that Punjab being the riparian state for Beas, Ravi and Satluj stakes its claim. The Indus basin covers Punjab while Yamuna basin covers Haryana. However, the conflict revolving around sharing of river water needs to be tackled with mutual understanding and objectivity.

4. The Indus Water Treaty. The Indus, one of the mightiest rivers, is dying a slow death due to construction of dams and barrages on it. The Sukkur barrage (1932), Gulam Mohammad barrage (1958) at Kotri and Tarbela and Chasma dams on Jhelum, a tributary of Indus have resulted in severe shrinking of the Indus delta. In 1960, the **Indus water treaty** was established in which Indus, Jhelum and Chenab were allocated to Pakistan and Ravi, Satluj and Beas were allocated to India. Being the riparian state, India has the right to construct barrages across all these rivers in Indian territory. However, the treaty requires that the three rivers allocated to Pakistan may be used for non-consumptive purposes by India without changing its flow and quality. By improving political relations between the two countries, it is desirable to think for an integrated development of the river basin in a sustainable manner.

• BIG DAMS-BENEFITS AND PROBLEMS

Benefits. India has the distinction of having the largest number (1850) of river valley projects (RVP) in the world. The execution of RVP's and dam building are the important steps of growth strategy (Table 3).

Table 3. Indian River Valley Projects.

S. No.	Projects	River	Purpose	Location	Benefits to States
1.	Bhakra Dam	Satluj	Irrigation and hydel power	Near village Bhakra, Bilaspur Distt., HP.	A joint venture of Punjab, Haryana and Rajasthan. Benefits (power) to Delhi and HP also. Govind Sagar reservoir.
2.	Hirakund Dam	Mahanadi	Irrigation, hydel power and flood control	Hirakund, Sambalpur Distt., Orissa	Orissa project, world's longest dam (4801 m. long)

3.	Nagarjuna Sagar Dam	Krishna	Irrigation and hydel power	Nandi Konda village, Distt., Nalgonda, AP.	Serving mainly Andhra Pradesh.
4.	Tungabhadra Dam	Tungabhadra a tributary of river Krishna	Irrigation and hydei power	Near hospet town in Karnataka	A joint project of AP & Karnataka.
5.	Kosi Project	Kosi, a tributary of river Ganga	Irrigation, power, flood control	The barrage on river Cosi near Hanuman Nagar in Nepal (Indo-Nepal border)	Serving mainly Bihar but Nepal also gets power.
6.	Damodar Valley Project	Damodar, Hugli	Irrigation, power, flood control	All dams lie in Bihar but Durgapur Barrage is in W. Bengal	Serving both Bihar and West Bengal. Irrigation of navigation and flood control in West Bengal only.
7.	Rihand Dam	Rihand, a tributary of river Sone	Hydel power	At Pipri, Mirzapur Distt. (U.P.)	It is mainly a hydel project, serving largely UP and the adjoining areas.
8.	Mettur Dam	Cauvery	Irrigation & hydel power	In Tamil Nadu	Very old river valley project serving the state (Cauvery is the world's best utilised river).
9.	Mayurakshi Project	Mayurakashi a tributary of Hugli	Irrigation, hydel power & flood control	In West Bengal	Serving in West Bengal mainly.
10.	Rajasthan Canal Project	From river Satluj	Irrigation	Taking off from river Satluj at Harike, it runs through Punjab, Haryana & Rajasthan	Irrigation in Rajasthan only, Ganga nagar distt. getting maximum benefits. Punjab & Haryana have only the feeder section of Feeder canal.
11.	Sharavathi Hydro electric Project	Sharavathi, a short westward flowing river	Hydel power	Harnessing Jog Falls in Karnataka	One of the largest hydel power projects in the country, serving mainly Karnataka.

- Big dams, the Temples of modern India, are regarded as symbol of national development due to their multiple uses.
- Dams have tremendous potential for economic upliftment. Dams provide employment to the tribals, generate electricity, supply irrigation water, drinking water in remote areas, reduce water and power shortage, promote navigation and fishery as well as help in checking floods, famines and drought.
- **Narmada** river valley project, largest in the world, consists of 30 big and about 3000 smaller dams spanning the states of Maharashtra, Gujarat, Madhya Pradesh and Rajasthan. It is expected to irrigate 1.23 lakh hectare and generate 1000 MW of power.
- Aswan dam, across the river Nile in Egypt, is today a boon to the Egyptian economy.

Environmental Problems. There are several issues and problems due to which big dams become a subject of controversy. The impacts can be at the upstream as well as downstream levels.

1. Upstream Problems.

- Displacement of tribal and native people.
- Deforestation and loss of biodiversity.
- Siltation and sedimentation of reservoirs.
- Stagnation and water logging near reservoirs.
- Changes in fisheries and spawning grounds.
- Breeding of vectors and spread of debilitating diseases.
- Reservoir induced seismicity causing earthquakes.

- Growth of aquatic weeds.
- The biggest economic and environmental cost of RVP's is the submergence of large tracts of dwellings, roads, railways, beautiful stretches, forests, farmlands and wildlife habitat.
- Narmada RVP will submerge 91,350 ha of land out of which 40,325 ha is forest. About 2 lakh people were affected severely and 30,000 tribals were displaced.

2. Downstream Impacts.

- Water logging and salinity due to over irrigation.
- Reduced water flow and silt deposition in river.
- Salt water intrusion at river mouth.
- Flash floods. Loss of land fertility.
- Outbreak of vector-borne diseases.
- Micro-climatic changes.

Conclusion. Although dams are built to serve the society with multiple uses but they have serious side effects. That is why now there is a shift towards construction of small dams or mini-hydel projects at appropriate sites.

• MINERAL RESOURCES

The term **mineral resources** refers to a wide variety of materials obtained from earth. Minerals are naturally occurring inorganic, crystalline solids having a definite chemical composition and characteristic physical properties. Most of the rocks are composed of a few common minerals like quartz, feldspar, biotite, dolomite, calcite etc. These minerals, in turn, are composed of some elements like silicon, oxygen, iron, magnesium, calcium and aluminium etc.

Categories of Minerals.

(i) Non-metallic minerals, *e.g.*, graphite, diamond, quartz, feldspar.

(ii) Metallic minerals, *e.g.*, bauxite, laterite, haematite etc.

(iii) Energy generating minerals. Coal, oil and natural gas.

Minerals are sometimes classified as critical and strategic. **Critical minerals** are essential for the economy of a nation, *e.g.*, Fe, Al, Cu, Au etc. **Strategic minerals** are required for the defence of a country, *e.g.*, Cr, Co, Pt, Mn.

Uses and Exploitation of Mineral Resources.

Minerals find extensive use in domestic, agricultural, industrial and commercial sectors and thus form a very important part of any nation's economy. The main uses of minerals are :

- Development of industrial plants and machinery.
- Generation of energy, *e.g.*, coal, lignite, uranium.
- Construction, housing, settlements.
- Defence equipments—weapons, armaments.
- Transportation means.
- Communication—telephone wires, cables, electronic devices.
- Medicinal system—particularly in Ayurvedic therapy.
- Formation of alloys for various purposes (*e.g.*, phosphorite).
- Agriculture—as fertilizers, seed dressings and fungicides (*e.g.*, Zineb containing zinc, Maneb-containing manganese etc.).

- Jewellery, *e.g.*, gold, silver, platinum, diamond.

The reserves of metals and the technical know-how to extract them have been the key elements in determining the nation's overall prosperity. Out of the various metals, the one used in maximum quantity is iron and steel (740 million metric tonnes annually) followed by manganese, copper, chromium, aluminium and nickel. The major world reserves of most of the minerals are USA, Canada, South Africa, Australia and CIS countries.

Table 4. Major uses of some minerals.

Metallic minerals	Major uses
Iron	Heavy machinery, steel production and transportation means.
Aluminium	Packaging food items, transportation, utensils, electronics.
Chromium	For making high strength steel alloys and in textile and tanning industries.
Copper	Electric and electronic goods, cables and vessels.
Lead	Leaded gasoline, car batteries, paints, ammunition.
Manganese	For making high strength, heat resistant steel alloys.
Platinum group	Use in automobiles, catalytic converters, electronics, medical uses.
Gold	Ornaments, medical use, electronics and in aerospace.
Silver	Photography, electronics and jewellery.
Non-metallic minerals	
Silicate minerals	Sand and gravel for construction, bricks, pavings etc.
Limestone	Used for concrete, building stone, used in agriculture for neutralising acid soils, used in cement industry.
Potash, phosphorite	Used as fertilizers.
Sulphur pyrites	Used in medicine, car batteries and in industry.

Some Major Minerals of India.

1. Energy Generating Minerals.

Coal and lignite. Madhya Pradesh, West Bengal, Jharkhand, Orissa, Andhra Pradesh.

Uranium (Pitchblende and uranite ore). Rajasthan (Ajmer), Jharkhand, Andhra Pradesh (Nellore, Nalgonda), Meghalaya.

2. Other Commercially Used Minerals.

Iron (Haematite and magnetic ore). Tamil Nadu, Karnataka, Madhya Pradesh, Andhra Pradesh, Maharashtra, Goa.

Aluminium (Bauxite ore). West Bengal, Maharashtra, Madhya Pradesh, Tamil Nadu, Jharkhand.

Copper (Copper pyrites). Rajasthan (Khetri), Bihar, Jharkhand, Karnataka, West Bengal, Andhra Pradesh, Uttarakhand.

The most important ingredient of today's economy like silver, tin, titanium, cadmium, chromium, zirconium, zinc, lead etc. are available in India.

Environmental Impacts of Mineral Extraction.

The effects of excessive mineral extraction and consumption are drastically serious which may damage the entire biosphere, rapidly deplete high grade mineral deposits, cause wastage and dissemination of mineral wealth.

Environmental concern arises from the impacts of extraction and processing of these minerals during mining and smelting etc.

Indian Scenario.

India is the producer of 84 minerals, the annual value of which is Rs. 50,000 crores. Mining is responsible for about 10% of the world's energy consumption. Mining has created some of the largest environmental disaster zone in the world. Six major mines in India causing severe problems are listed below.

(i) Jaduguda uranium mine, Jharkhand. Exposed local people to radioactive hazards.

(ii) Jharia coal mines, Jharkhand. Underground fire leading to land subsidence and forced displacement of people.

(iii) Sukinda chromite mines, Orissa. Seepage of Cr (VI) into river. Chromium is highly toxic and carcinogenic.

(iv) Kudremukh iron ore mine, Karnataka. Causes river pollution and threat to biodiversity.

(v) East coast bauxite mine, Orissa. Land encroachment and issue of rehabilitation unsettled.

(vi) North-eastern coal fields, Assam. Very high sulphur contamination of ground water.

Impacts of Mining.

Mining is done to extract minerals from deep deposits in soil by **sub-surface** mining or from shallow deposits by **surface mining.** The former method is more destructive, dangerous and expensive including risks of occupational hazards and accidents.

1. **Devegetation of landscape.** Soil damage during surface mining is inevitable as it leads to loss of grazing and fertile land, soil erosion, sedimentation, damage to flora and fauna. Open cast coal mining alone eroded 2,00,000 hectares of fertile land.

2. **Subsidence of land.** Underground mining causes subsidence of land which results in tilting of buildings, cracks in houses, buckling of roads and bending of rail tracks.

3. **Ground water contamination.** Mining disturbs the natural hydrological cycle. Acid mine drainage from sulphur bearing minerals leaches toxic metals to ground water.

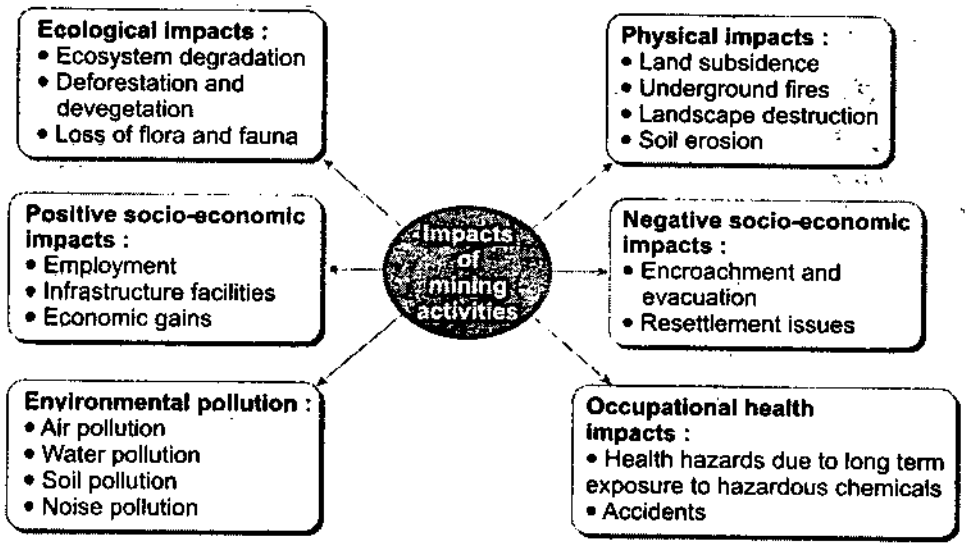


Fig. 1. Impacts of mining activities.

4. **Surface water pollution.** Cyanide solution from gold mining severely pollute surface water.

5. **Air pollution.** Smelting results in emission of particulates, NO_x, SO_2, CO_2 thereby causing global warming, acid rain and climatic changes.

6. **Dust and noise pollution**, is caused during loading, crushing and drilling operations.

7. **Occupational health hazards.** Most of the miners suffer from respiratory and skin diseases due to constant exposure to the suspended particulates and toxicants. Such diseases include bronchitis, asthma, black lung disease, silicosis and asbestosis.

8. **Ecological damage.** Mining leads to erosion of natural biodiversity.

9. Mining displace people from their resource base.

Remedial Strategies.

These strategies include storage of top soil and fertile land, water retentivity, improvement of hydrological regime, selection of ecologically suitable species, natural regeneration, enlisting people's participation and social fencing etc. Modified mining techniques from dig dump mining to continuous system has been adopted along with **sequential techniques.** Recycling of all metallic waste is cost effective and eco-friendly.The adverse impact of mining can be minimised by adopting eco-friendly technology (like **microbial leaching technique** for extraction of gold with the help of bacterium Thiobacillus ferrioxidans). National Wasteland Development Programme should consider climate, soil texture, rainfall pattern, population and other biomass needs.

Conservation of Mineral Resources.

Following steps may be adopted to conserve mineral resources.

- Economy in the use of mineral resources.
- Making finished products to last longer.
- Use of less precious substitutes.
- Renovation, recycling and reuse of metals.
- Applying effective techniques to recover materials from minerals.
- Search of new earth's treasures.
- Protection of existing mineral deposits.

• CASE STUDIES

Mining and Quarrying in Udaipur.

The large scale mining in Udaipur (Rajasthan) for soapstone, building stone, rock phosphate and dolomite have caused several adverse impacts on environment. The mines spread over 15,000 hectares and about 150 tonnes of explosives are used in blasting per month. The Maton mines have badly polluted the Ahar river. The hills around the mines are devoid of vegetation and suffering from acute soil erosion. The waste water flows towards a big tank of Bag Dara. This effluent is used for irrigation due to scarcity of water. The blasting activity has adversely affected the fauna and many animals have disappeared from the mining area.

Mining In Sariska Tiger Reserve in Aravallis.

Aravalli range is spread over about 692 kms in the North-West India and its hill region is very rich in biodiversity as well as mineral reserves like marble, granite and quartzite in abundance. Mining operations within and around the Sariska

Tiger Reserve has left many areas permanently infertile and barren. The precious wildlife is under serious threat. We must preserve the Aravalli hills as a national heritage. On December 31, 1991, the Supreme Court has given a judgement in response to a Public Interest Litigation of Tarun Bharat Sangh (an NGO) wherein both Central and State Governments of Rajasthan have been directed to ensure that all mining activity within the park be stopped. More than 400 mines were shut immediately. But illegal mining is still in progress.

Proposed Uranium Mining in Nalgonda, A.P.

The Uranium Corporation of India proposed to mine uranium from the deposits in Lambapur and Peddagattu villages of Nalgonda in Andhra Pradesh and a processing unit at about 18 kms at Mallapur. The proposed mines are just 1 km from human habitation, 10 kms from Nagarjun Sagar Dam and barely 4 kms from the Akkampalli reservoir which is Hyderabad's new source of drinking water. It is estimated that 20 years of mining would generate about 7.5 million metric tonnes of radioactive waste of which 99.9% will be left behind. The villagers are likely to be affected by the radioactive wastes.

Though IUCL claims that there won't be any accidents but no one deny that it is a highly hazardous industry and safety measures cannot be overlooked. The pathetic condition of Jaduguda uranium mines in Jharkhand where there is a black history of massive deaths and devastation have outraged the public, who do not want to be repeated in Nalgonda. The proposed mines would cover about 450 hectares of Yellapurum Reserve Forest and Rajiv Gandhi Tiger Sanctuary. The public hearing held in February 2004 witnessed strong protest from NGO's and many villagers. However, the fate of the proposed mining is yet to be decided.

• FOOD RESOURCES

The main food resources are wheat, rice, maize, barley, pulses, cereals, potato, sugarcane, sorghum, millet, oats, cassava, fruits, vegetables, milk and sea food etc. About 4 billion people in the developing countries have wheat and rice as their staple food. Fish and seafood contribute about 70 million metric tonnes of high quality protein to the world's diet. But we have already surpassed sustainable harvests of fish from most of the oceans.

World Food Problems.

World grain production increased about three times during the last 50 years. But at the same time population growth in developing countries increased at such a rate that it out stripped food production. Every year about 50 million people die of malnutrition and starvation. India is the third largest producer of staple crops that is, wheat, maize, gram, rice yet about 300 million people are still undernourished **(Table 5)**. They are receiving less than 90% of the minimum required calorie intake of 2500 cals per day (as estimated by FAO of United Nations).

Table 5. Impact of nutritional deficiency.

Deficiency	Health effects	Deaths per year (in millions)
Proteins	Stunted growth, Kwashiorkor, marasmus	15–20
Iron	Anaemia, retardation of growth	0.75–1.00
Iodine, Vitamin A	Goitre, cretinism, night blindness	0.40–0.50

Food crisis is directly linked to population explosion. India has only 50% land as compared to USA, but it has nearly three times population to feed. In some Third World countries, the food shortage is killing every year as many people as were killed by the dropping of atom bomb in Hiroshima during World War II in 1946. These startling statistical figures emphasize the need to increase our food production, its equitable distribution and control of population. The **World Food Summit,** 1996 has set the target to reduce the number of undernourished to just 50% by 2015.

CHANGES CAUSED BY OVERGRAZING AND AGRICULTURE.

Beside natural factors like rainfall, climate and soil texture, crop production is also affected by overgrazing, traditional agriculture and modern agriculture.

(A) Impacts of Overgrazing.

Livestock wealth, maximum in India, plays a crucial role in the country. The huge population of livestock grazing on grassland or pasture surpass the carrying capacity. **Carrying capacity** of any system is the maximum population that can be supported by it on a sustainable basis. However, most often, the grazing pressure is so high that its carrying capacity is crossed and the sustainability of the grazing land fails.

1. **Land degradation.** Overgrazing degrades the land, removes vegetal cover, declines soil moisture and organic recycling. Due to trampling by cattle the soil loses infiltration capacity, soil structure, hydraulic conductivity, humus content and soil fertility.

2. **Loss of useful species.** Overgrazing adversely affects the composition of plant population and their regeneration capacity. Several juicy fodder giving species like Panicum, Cenchrus, Dichanthium are replaced by unpalatable and poor quality thorny plants such as Lantana, Argemone, Parthenium.

3. **Soil erosion.** Due to overgrazing by cattle, the cover of vegetation almost gets removed from the land. The soil becomes exposed and gets eroded by the action of strong wind and rainfall. The grass roots are very good binders of soil. When the grasses are removed, the soil becomes loose and prone to soil erosion.

(B) Impacts of Traditional Agriculture.

Traditional agriculture involves small fields, simple tools, rain water, organic fertilizers and a mix of crops. It results in low production.

1. **Deforestation.** Shifting cultivation (slash and burn) results in deforestation and soil erosion.

2. **Depletion of nutrients.** Slash and burn cultivation destroy the organic matter and makes the soil nutrients poor.

(C) Impacts of Modern Agriculture.

Modern agricultural techniques which are geared towards bumper crop production to meet the ever growing demands of rapidly increasing population are exploring new agro-technologies to feed the masses. With the extensive use of high output techniques employing hybrid seeds of high yielding varieties (Green Revolution) and abundant irrigation water, fertilizers and pesticides, the world is heading towards a complex array of environmental problems more severe than ever before. Although Green Revolution boosted the food production but its fallout become evident since 1990s as listed below :

1. Fertilizers related problems.

- Fertilizer enriched soil can not support microbial flora. Hence there remains poor humus and less nutrients while the soil can readily become eroded by wind and water.

- It is reported that there is a 30% decline in protein and carbohydrate content when corn, maize, gram and wheat crops were grown on soils fertilized with NPK fertilizers.
- Potassium fertilizers in soil decreases the valuable nutrient ascorbic acid (vitamin C) and carotene in vegetables and fruits. Fertilized soil produces bigger sized vegetables and fruits which are more prone to pest, insects and diseases.
- Phosphatic fertilizer like DAP (that of P_2O_5) is considered detrimental to crop production. It may lead to Fe, Cu and Zn deficiency in plants.
- Cereal crops like jawar, maize and pearl millet grown on alkaline soil absorb higher amounts of fluorides and responsible for the spread of **fluorosis.**
- Excess use of fertilizers intensively reduces the ability of plants to fix nitrogen.
- Farmers use NPK fertilizers indiscriminately to boost up crop growth which cause **micronutrient** (Cu, Zn, Fe) **imbalance.**

2. Eutrophication. (Eu-more, Trophication-nutrition).

Agricultural run-off contains nitrogen and phosphorus fertilizers which reaches nearby water bodies. Excessive use of these fertilizers leads to over nourishment of these water bodies and gives rise to the phenomenon of eutrophication. Thus the lake soon gets filled up with the extensive growth of algal bloom. Decomposition of algal bloom leads to oxygen depletion in water. Aquatic organisms begin to die and the lake becomes a dead pool of water. [Also refer to the Effects of Eutrophication in Water Pollution].

3. Nitrate pollution.

- Excessive use of nitrogenous fertilizers, called the **miracle drug** of farming, lead to accumulation of nitrate in the soil which are transferred to man through plants. Nitrates, being highly soluble, go into drinking ground water and become toxic when its concentration exceeds **90 ppm.** In human body these nitrates and nitrites are converted to nitroso and nitrisoamines which are suspected as agents of **stomach cancer.**
- Nitrate in water causes cyanosis (blue jaundice) in children and methaemoglobinemia or **blue-baby syndrome** in infants where nitrite interferes with oxygen carrying capacity of blood.
- Nitrate poisoning in animals have been reported due to consumption of vegetation grown in nitrate rich soil. According to H.H. Koepf, an eminent soil chemist, modern agriculture can honestly claim two notable crops-disease and pest but now a third factor (nitrate, nitrite fertilizers) can be frequently added to soil contaminants.

4. Pesticide related problems.

Though some pesticides (DDT) are banned, they still show small doses in foods. Increased productivity of crops leads to greater dependency on agrochemicals creating new problems to be faced in future. [Also refer to Effects of Pesticides in Land Pollution].

5. Inducing pest resistance species.

New generations of pests develop resistance to pesticides which survive even after pesticide spray. At present, about 30 pest species are known to be immune to all types of pesticides and are called super pests.

6. Biological magnification or Biological amplification.

Many pesticides are non-biodegradable so they persist in the food chain. For instance, concentration of DDT continuously increases in successive trophic level

in food chain. Thus DDT level builds up from 0.04 ppm in planktons, 0.94 ppm in minnows, 5 ppm in fish to 75 ppm in geills. Man occupies the highest trophic level in the food chain, hence gets a high dose of pesticide. Organochlorine insecticides have the greatest magnification because they have a little affinity for lipids and are quite persistent ecopoisons.

7. Impacts from high yielding varieties. (HYV).

Applications of seeds of HYV produce monoculture that is, same species (genotype) grown over large areas. Such monoculture is vulnerable to attack by pathogen, which spreads quickly devastating the crops.

8. Water logging.

Excessive irrigation of crop lands for good crop fertility leads to water logging. In absence of adequate drainage, excess water seeps into the underlying water table. Soil gets fully drenched and roots of plants have insufficient air for respiration. Mechanical strength of the soil declines, plants get heavily lodged and crop yield falls. Punjab and Haryana have faced water logging problems as a result of extensive irrigation by canal water. Consequently there is a sharp decline in crop fertility. Preventing excessive irrigation, sub-surface drainage technology and bio-drainage with trees like Eucalyptus are some of the remedial measures to prevent water logging.

9. Salinity problems.

Over irrigation of crop lands gives rise to salinity which contains dissolved salts. Accumulation of salts such as NaCl, Na_2SO_4, $CaCl_2$ and $MgCl_2$ etc. in the soil profile causes the soil to become saline. Thousands of hectares of land in Punjab and Haryana have been affected by soil salinity. Salinity causes stunted plant growth and reduces crop yield. The **best method** of getting rid of salinity is to flush out by applying fresh water to such soils. Another method is laying underground network of perforated drainage pipes for flushing out the salts slowly. This system has been tried in CSSRI at Sampla, Haryana. The Central Soil Salinity Research Institute (CSSRI) in Karnal, Haryana has successfully converted barren land to productive land.

• CASE STUDIES

Salinity in Haryana and Punjab. The first alarming report of salt affected wasteland formation related to irrigation practices came from Haryana and then Punjab in 1958. Several villages in Panipat, Rohtak and Delhi lying near western Yamuna canal were suffering from destructive saline efflorescence. The **Reh Committee** drew the attention of government on some vital points indicating the relationship between drainage and spread of usar and **reh soils.**

Water Logging in Punjab, Haryana and Rajasthan. In Punjab, the floods of 1950, 1952, 1956, 2010 resulted in aggravated water logging with severe drainage problems. Introduction of canal irrigation in Haryana have raised the water table followed by water logging and salinity in many irrigated areas causing huge economic losses as a result of fall in crop productivity. Rajasthan too has suffered badly from the biggest irrigation project—Indira Gandhi Canal Project. A vast area in Western Rajasthan has changed from water starved wasteland to that of water soaked wasteland.

• ENERGY RESOURCES

GROWING ENERGY DEMANDS.

Humanity today is on the verge of another catastrophe, *i.e.*, the energy crisis. Increasing industrialisation and unsuitable consumption patterns are escalating

the environmental problems due to depletion of resources and energy. The unsustainable use of renewable resources and generation of toxic materials are creating problems to biodiversity, environment and human health.

Energy use is not an end in itself. **Energy plays a dual role.** It is an input into the productive sectors of the economy, industry and agriculture as well as supporting infrastructure of transport. It is also a consumer good, energy consumed in households has a direct impact on the quality of life. In India, per capita energy consumption is one-fourth of the world average that is, only 5 million BTU, while it is 200 million BTU in USA, 125 million BTU in UK and 50 million BTU in Japan.

The development of energy source is highly capital intensive and large investments are needed for meeting the demands of energy for different consuming sectors. It would be really ironic if **fuel becomes more expensive than food**. Gulf war and Iran-Iraq war had also brought into sharper focus the energy predicament.

RESOURCES OF ENERGY.

Energy is the capacity for doing useful work. Energy resources are broadly classified as primary and secondary.

A. Primary Energy Resources. These resources are mined or obtained from the environment. Examples are :

1. **Fossil fuels.** Coal, lignite, crude oil, natural gas etc.
2. **Nuclear fuels.** U, Th, D_2 and other radioisotopes.
3. **Hydro energy.** It is the energy of falling water.
4. **Solar energy.** Electromagnetic radiation from the sun.
5. **Wind energy.** The energy from moving air used by wind mills.
6. **Geothermal energy.** The heat from the underground streams or the heat stored in hot rocks beneath the earth surface.
7. **Tidal energy.** Energy associated with rise and fall of tidal waters.

Primary Energy Resources can be further classified as follows :

(a) (i) **Conventional sources of energy.** Main conventional sources are thermal power, hydel power, nuclear power and fossil fuels.

(ii) **Non-conventional sources of energy.** These are solar energy, wind energy, geothermal energy, ocean energy and tidal energy.

(b) (i) **Renewable sources of energy.** These sources (also called non-conventional sources) are being continuously produced in nature and are inexhaustible. Examples include wood, geothermal energy, wind energy, tidal energy, nuclear fusion, gobar gas, biomass, solar energy etc.

(ii) **Non-renewable sources of energy.** These resources are finite and exhaustible. Once consumed, these sources can not be replaced by others. Examples include coal, timber, petroleum, lignite, natural gas, fossil fuels, nuclear fuels etc.

B. Secondary Energy Resources. These sources do not occur in nature but are derived from primary energy resources. Examples are petrol or gasoline, electrical energy from coal burning, H_2 obtained by electrolysis of H_2O.

World scenario of energy. Conventional sources of energy account for 90% of the world's production of commercial energy. Other sources account for : Oil 39.5%, coal 30%, natural gas 19.6%, hydro-electric 6.7% and nuclear 3.9%.

HYDROELECTRIC POWER.

Hydroelectric power (electricity from water) is the cleanest, cheapest and best source of electricity generation. Central Electricity Authority (CEA) has indicated the hydropotential of India at 84,000 MW at 60% load factor or 1,35,500 MW at 40% load factor. It is equivalent to 600 billion units of energy per year. But at present, only 16% or 6500 mega watts of hydroelectricity is generated. For **generation of electricity** from hydel project, it is necessary to utilise energy produced from the descent of water from higher to lower level. In practice, a water reservoir is constructed by means of dams in a river for storage of water. High dams are built to obtain a substantial amount of hydrostatic pressure. When stored water under high pressure is released from the upper level into a water driven turbine placed at a lower end, electricity is generated (Fig. 2). The hydel projects of Jaldhaka, Panchyet and Maithon constitute typical examples.

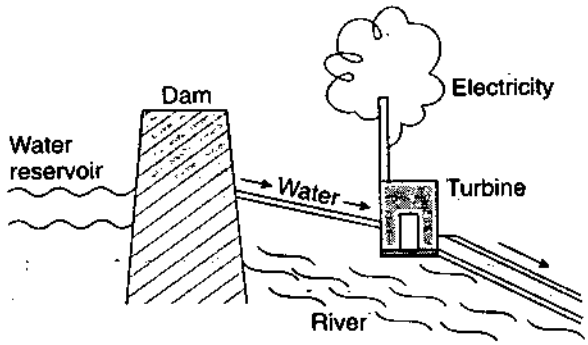


Fig. 2. Hydroelectricity hydel project.

In US, about 300 large dams generate 9.5% of its total electrical power production. In Venezuela, South America, 10,000 mega watts of hydroelectricity is produced which is equivalent to the production of electricity from 10 thermal power plants.

Advantages of Hydroelectricity.

1. Hydroelectricity is basically non-polluting renewable clean source of energy.
2. There is no emission of green house gases.
3. No consumption of fuel
4. No need of high technology.

Problems in the Development of Hydroelectric Power.

- Land acquisition,
- Environmental aspects,
- Techno-economic clearance,
- Statutory clearance,
- Construction machinery,
- Zero date disparity.

Limitations.

Hydroelectricity is still associated with serious problems.

1. Dams have drowned out beautiful stretch of rivers, forests, productive farm lands and wild life habitat.
2. Local people become refugees as they are uprooted from their houses.

3. Capacity of the reservoir gets reduced due to siltation.

4. Since water flow from the dam is regulated as per the requirement of power, dams play havoc downstream because water levels may change from extremes of near flood levels to virtual dryness and back to flood even in a single day.

Many developing countries have great potential for large hydel power projects but due to certain limitations, there is a lot of opposition from Environmental Protection Organisations and people.

NUCLEAR ENERGY.

Nuclear Energy from Nuclear Fission and Nuclear Fusion.

Nuclear energy can be generated by nuclear power (fission) reactors which are based on the fission of uranium-235 nuclei by thermal neutrons.

$$_{92}U^{235} + {}_0n^1 \longrightarrow {}_{51}Sb^{133} + {}_{41}Nb^{99} + 2.5\ {}_0n^1 + 200\ MeV$$

The energy from these nuclear reactions is used to heat water in the reactor and produce steam to drive a steam turbine. Thus energy is converted into electricity.

- Fission of 1 kg of U-235 releases energy equal to 1.7×10^{13} cals.
- 1 lb of U-235 ≡ 5 million lbs of coal ≡ 20 million lbs of TNT.
- 1 g of U-235 produces heat energy equivalent to 3 tonnes of coal or 14 barrels of crude oil.

Light water reactor (LWR), high temperature gas cooled reactor (HTGR) and fast breeder reactor (FBR) are viable for power generation. LWR consumes only U-238 and Th-232 to fissionable Pu-239 and Np-244.

Nuclear power contributes only 5% of total electricity generation.

Advantages of nuclear energy. Nuclear power plants do not emit polluting gases such as CO_2 and SO_2 like thermal power plants.

Limitations.

1. The major constraint in the use of nuclear fission power is the yield of large quantities of radioactive fission waste products which remain lethal for thousands of years.

2. Safe disposal methods have not been devised.

Nuclear fusion reactions are based on deuterium-deuterium and deuterium-tritium reactions. The latter is energetically more viable.

$$_1H^2 + {}_1H^3 \longrightarrow {}_2He^4 + {}_0n^1 + 17.6\ MeV$$

The deuterium-deuterium reaction promises an endless source of energy without any radioactive wastes, but the technological problems for harnessing fusion energy will take several years to solve.

THERMAL POWER.

Electricity is generated by combustion of coal in a furnace. This heat is utilised to produce steam at high temperature and pressure. Steam is then used to run a turbine which is linked with the generator producing electricity.

Coal-fired thermal power plants are operated on the above principle by mechanical rotation of the steam turbine. In India, thermal power contributes about 65000 MW of electricity, that is, 70% of the total power supply. Some of the major thermal power stations of National Thermal Power Corporation (NTPC) of India are at Singrauli and Rihand in UP, Farakka in West Bengal and Talchar in Orissa. They are the major source of thermal pollutants, flyash and decreased content of dissolved oxygen.

SOLAR ENERGY (Electromagnetic Radiation from the Sun)

Sun is the source of all energies on the planet earth. It is a large **nuclear reactor** where hydrogen gas is continuously burning at high temperature and pressure. Solar energy originates from the **thermonuclear fusion reactions** occurring in sun. The energy generated by sun into the space is received on the earth as electromagnetic radiant energy. Out of the solar radiations reaching the earth, 92% consist of radiations in the range 315 nm to 1400 nm, 45% of this radiation is in the visible region, 400 nm to 700 nm. The earth absorbs radiation mainly in the visible region and emits radiation in the infra red region (2 μ to 40 μ with maximum at 10 μ).

Energy Output.

The value of solar flux reaching the earth's upper atmosphere is estimated to be about 1400 watts m^{-2} min^{-1}. The heat equivalent of the solar radiation reaching the earth is 2.68×10^{24} Joules per year. The total energy out put of the sun is estimated at 3.45×10^{23} KWH. The average intensity of solar radiation is 2.1 to 2.5 kJ per cm^2 per day in India.

Location. India is located between 7° N and 37° N latitudes and the prospects of using solar energy is very bright indeed. If India can trap 1% of the incident radiation, it can generate many tonnes the energy of its actual requirement at present. But it utilises only 25×10^{-7}% (13×10^7 KWH per year) of the incident solar radiation (5×10^{15} KWH per year). Only 0.5% of solar energy reaching the earth is trapped by photosynthesis which is the energy source for the ecosystem.

Production of Electricity using Solar Energy.

Solar energy can be used either by absorbing radiations to produce heat or by converting it directly into electricity by following methods.

1. Photovoltaic Cells (Solar Cells). Solar panels or a large number of solar cells are connected in series parallel combination to obtain the required amount of power. These cells when exposed to solar radiation give direct current (DC) which can be converted into alternating current (AC) using inverters. The **silicon solar cell**, developed for the space programme consists of a sandwich of ***n*-type and *p*-type** silicon semiconductors, the charge separation is developed across the junction between them and electricity is produced (Fig. 3).

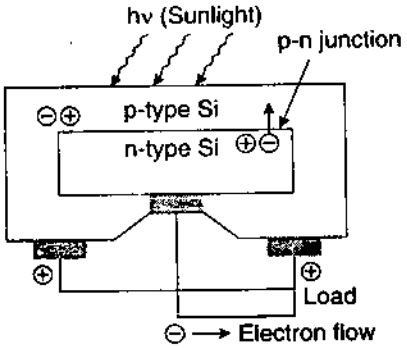


Fig. 3. Solar cell for generation of electricity.

***n*-type Silicon cell (semiconductor).** When Si lattice contains an impurity of As, which contains 5 electrons in the outer shell, 4 of these electrons form bonds with Si while the fifth electron is available for conducting current. Such solids are called n-type semiconductors.

***p*-type Silicon cell (semiconductor).** When Si lattice contains some atoms of indium (In), with three electrons in the outer shells the covalent bonding is incomplete, some sites being vacant, which constitute positive (+ve) holes. If these holes are filled by adjacent electrons, they form other holes and by migration, they carry current. Such solids are called *p*-type Si cells. If a crystal of Si is prepared such that one part is *p*-type (which conducts positive charge) and the other *n*-type (which conducts negative charge), the *p-n* junction will permit current from an

external source of flow through it in one direction. The silicon cell produces only 15% electricity and is quite expensive since very high grade crystalline Si is required.

With innovation in manufacturing process and more advanced technology, the photovoltaic power plants may be producing power nearly at the same cost as traditional power plants. Experiments with vehicles run on PV cells are under way using ultra-efficient designs. Solar photovoltaic cells deteriorate due to exposure to weather. Other **solar cells** developed are CdS (n-type), Cu_2S (p-type), gallium arsenide and indium phosphide.

2. Solar Trough Collectors (Invented by Charles Abbott). Sunlight hitting the solar trough collector is reflected onto a pipe and heat the fluid circulating through it. The heated fluid is used to boil water, thereby generating steam to run turbo generator.

3. Power Tower. In this method, an array of sun tracking mirrors is used to focus sunlight on a large area of land onto a boiler mounted on a tower. The intense heat produces steam in the boiler which drives a turbo generator to generate electricity.

4. Solar Furnace. Here thousands of small plane mirrors are arranged in concave reflectors which collect the solar heat and produces high temperature upto 3000°C.

Applications of Solar Energy.

The **best application** of solar energy is in heating buildings and providing hot water which in developed countries like USA, consumes about 25% of the fuel supply. Figure 4 illustrates the detailed heating system in a solar heated house. Sunlight is collected on plates in the roof and heat transferred to a circulating water system. It has been calculated, that in US, an average house with a collection area of 1300 ft^2 can get its energy supply for heating and hot water in December by this method.

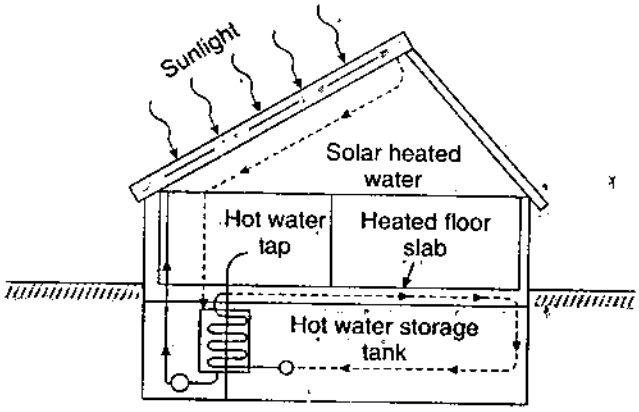


Fig. 4. Heating system in a solar heated house.

- The use of solar energy is a completely benign operation. Solar energy can be used as **solar heat** by several gadgets such as solar cooker, solar dryer, solar water heater, solar distillation, space conditioning, green house technology, solar air crafts.
- Solar energy can also be used as solar electricity by PVC or solar cells. Solar photovoltaics could be installed in remote areas in forests and deserts where installation of electric cables are cost-prohibitive.
- Solar energy being non-polluting and non-depletable is considered as renewable energy and fits into the principle of sustainability.

- Solar cells are widely used in electronic watches, calculators, traffic signals and artificial satellites. Because of their non-polluting nature, solar cells are known as **clean and green cells.**

Limitations of Solar Energy.

- The major constraint is that sunlight is diffuse and intermittent.
- Density of solar energy is low as compared to oil, gas or coal etc.
- CO_2 produced while forming silicon from silica increases atmospheric temperature. Silicon dust is also an occupational hazard.
- Cadmium is used in fabricating thin film solar cells which is carcinogenic. However, only traces of Cd is released from discarded PV panels.

WIND ENERGY.

Principle. In India, wind power can be usefully exploited for the generation of electricity as there are large coastal, hill and desert areas. The concept of air plane type propeller blades turning a generator geared to shaft is applied. **Wind turbines,** comprising of two blades, convert kinetic energy of the wind into electrical energy.

Operation. The flow of air against the windward side of the blades creates suction on the reverse side, which turns the rotor shaft on which the blades are mounted. This rotor turns the generator which is linked directly to the electricity grid. When the wind speed is greater than 25 m/s, a disc brake stops the turbine from operation.

The operation of the wind turbine is monitored and controlled by a **computer** in the bottom of the tower. The computer receives information regarding wind speed and wind direction via an anemometer and a wind wave mounted on the top of turbine housing. Currently, wind turbines have horizontal axis with high hub heights (328 ft) and large rotors (180 ft). A **prototype electrical generator** developed 20 kW power at Rensselaur polytechnic Institute in Troy, New York.

Classification of Wind Machines.

Wind machines used for generating electricity may be classified into three categories :

1. **Mini-converts** with average output of 1 KWe are used to run small irrigation units, light houses and ranger stations.

2. **Machines** with average output of 50 KWe are used in rural industries, isolated houses, pumping of irrigation water and space heating.

3. **Wind farms** with average outputs in the range from 500 KWe to many MW supply power to electrical power grids. A modern wind farm may contain 500 wind turbines connected to a transmission grid. Wind mills used extensively in USA, England and Russia, work on the principle of converting kinetic energy of the wind to mechanical energy. By the year 2009, more than 13000 mega watts of wind power had been installed world wide. California alone had 1600 MW of wind power in use to provide enough electricity for over 7,50,000 homes.

Advantages of Wind Energy.

- Wind energy is a renewable and economically competitive energy source.
- Wind machines can be built on shore or off shore.
- Cost effective and reliable wind power generators are now being produced.
- Wind machines are useful in supplying electric power to remote and rural areas.

- Dispersed wind energy systems are more environmentally benign than any other alternative source of energy.

Limitations of Wind Energy.

- Low energy density.
- Wind is variable, irregular and intermittent.
- Design, manufacture and installation of wind turbines is complex due to varying atmospheric conditions where they have to operate.
- Small units are more reliable but have higher capital cost per KWh. Large units require high technology.
- Requires energy storage batteries which indirectly contribute to environmental pollution.
- Requires vast open areas which are far away from load centres.
- Wind generators may interfere with habitats, cause noise pollution and aesthetic degradation.

GEOTHERMAL ENERGY.

Geothermal energy is the exploitation of heat energy from the molten core of the earth. In volcanic regions, holes can be drilled into the hot-rocks and make the rising steam from ground water to drive turbo generators to produce electric power. The high temperature (> 150°C) geothermal resources are exclusively used for power generation.

The world's largest geothermal energy production facility exists at a location called **Geysors** near **San Fransico in US.** In 2008, its electrical output was 14.3 billion kW, which is equivalent to the power produced by two large nuclear power plants. Similar geothermal facilities exist in Mexico, Japan, Italy and Iceland generating a total power of about 3000 MW. Geothermal sources provided more than 7% of electricity in California. Worldwide, geothermal energy totalled more than 8 million kW or about 3% of the 3180 kW used globally.

Advantages of Geothermal Energy.

- Geothermal resources in the moderate temperature range (90°C to 150°C) can be used for space heating, for generating industrial process steam, green houses and aqua culture.
- Coupled with heat pumps, the low temperature (< 90°C) geothermal resources are used for home heating and cooling.

Limitations of Geothermal Energy.

- Natural steam vents occur only in few regions whereas hot dry rocks are available in almost all places.
- Hot steam coming to the surface is usually contaminated with the salts and sulphur compounds. Some of these contaminants are highly corrosive to turbines.
- SO_2 pollution from a geothermal plant may be as much as that of a high sulphur coal based thermal power plant.
- Hot brine released into surface waters may be ecologically hazardous.

OCEAN ENERGY.

India's first power plant generating electricity is commissioned at Vizhinjam fishing harbour in Kerala to provide energy of 150 MW in a year. The conversion of ocean thermal energy into electrical energy is about 150 MW in Andaman and Nicobar islands.

Sources of Energy From Oceans. The biggest treasures of the world lie hidden in the sea. Oceans are, therefore, known as our last frontier. The various

methods of extracting energy from oceans are :

- Ocean winds, Ocean waves, Ocean tides,
- Ocean currents, Ocean geothermal,
- Ocean thermal energy conversion.

Energy from Ocean Waves.

Ocean waves splash on ocean shores at tremendous speed. The mechanical energy in this process can be harnessed and converted into electrical energy. In a large chamber, sea water is enclosed by oscillating water column method. Ocean wave enters the chamber through an inlet pipe and forces the enclosed water upward at terrific speed. This will exert hydraulic pressure on the enclosed air which in turn can rotate a turbine.

It has been found that in the middle of North Atlantic Ocean, each wave per one metre height can generate 90 kW electricity whereas on the ocean shore the waves can generate 25–75 kW. During storm, the generation level can rise upto 5 mega watts.

Limitation. Energy production from ocean is expensive at present but it has immense potential which can be exploited in future with advanced technology.

Sea is unpredictable in energy generation at best but devastating at worst (such as when Tsunami hit in the South Pacific).

TIDAL POWER.

A lot of energy is inherent in the rise and fall of the tides and ocean waves. One of the simple scheme to utilise tidal energy is to construct a dam across the mouth of a bay and mount turbines in the structure. The incoming tide forming through the turbines generates power. As the tide shifts, the blades may be reversed so that out flow water continues to generate power. Tidal power plants are in operation in Russia, France and Nova Scotia. There are 15 locations in the world to generate tidal power. **In India**, the probable sites for exploration of tidal energy are Gulf of Kutchch and Sunderbans and also near Andaman, Nicobar and Lakshadeep islands. The **Bay of fundy** in North America has the large tidal power plant. Tidal power plants are accompanied by the **adverse environmental effects** because of the dams which may trap sediments, impede the migration of marine organisms, change water circulation and cause mixing of fresh water with salt water.

• FOSSIL FUEL BASED ENERGY

Coal, crude oil and natural gas are called fossil fuels because all of them once were living matter.

COAL (BLACK DIAMOND).

Coal is substantially more abundant than oil or gas, the total coal reserve being 7.4×10^{12} metric tonnes, which is equivalent to 4.7×10^{22} calories. This is 1000 times more than the total world energy consumption from all fuels.

Coal, derived from partial degradation of plants, is mainly of three types namely **lignite** (70% C), **bituminous** (80% C) and **anthracite** (90% C). Anthracite, a hard, clean burning, low sulphur coal is most desirable of all the coals. **Typical approximate composition of coal is**

$$C_{100}\,H_{85}\,S_{2.1}\,N_{2.1}\,O_{9.5}$$

Environmental Problems Associated with the Use of Coal.

- On combustion, coal emits SO_2 which forms sulphuric acid in air and causes acid rain.

- CO_2 is also produced which is a green house gas responsible for causing global warming.
- Coal is less convenient to use than petroleum or natural gas.

Measures Adopted to Use Coal.

- Minimise impact of coal mining.
- Remove ash and sulphur from coal prior to combustion.
- Remove ash and SO_2 from stack gas after combustion.
- Convert coal to liquid and gaseous fuels free of ash and sulphur.

High Grade Ash Free Coal.

High grade ash free coal is produced as **Solvent Refined Coal** (SRC) by suspending pulverized coal in a solvent by treating with 2% of its weight of H_2 at 1000 psi and 450°C. The product is a semi solid, m.p. 170°C having a calorific value of 16000 Btu/lb comparable to best anthracite coal.

METHANOL.

Methanol, CH_3OH is a convenient liquid fuel which can be produced from coal. On a commercial scale, it is produced by the reaction of CO and H_2 obtained from coal, oxygen and steam in presence of Cu based catalyst.

$$CO + 2H_2 \xrightarrow[250°C]{\text{50 Atm. pressure}} CH_3OH$$

15% Methanol makes an excellent additive to gasoline. It has a high octane number of 106, improves fuel economy and cuts down the emission of all automotive pollutants.

PETROLEUM AND NATURAL GAS.

The consumption of petroleum and natural gas is maximum in USA. The **world reserve** of petroleum is about 800 billion barrels, which is likely to be exhausted in the next century. **Natural gas** is a better fuel than coal and petroleum since on burning, it produces less CO_2. For production of one unit of energy, mineral oil, coal and wood, on burning produces 35%, 75% and 85% more CO_2 than natural gas.

• ALTERNATE ENERGY SOURCES

BIOMASS ENERGY.

Biomass is the organic matter produced by plants or animals which include crop residues, wood, dung, manure, sewage and agricultural wastes etc. Biomass energy refers to the direct burning of biomass and converting them to a fuel. It is of following types.

1. Energy Plantation (Indirect use of Solar Energy).

Solar energy is trapped by green plants through photosynthesis and converted into biomass energy. Fast growing trees like cotton, wood and Leucaena, non-woody herbaceous grasses, crop plants like sugarcane, sweet sorghum, sugar beet, aquatic weeds like water hyacinth, sea weeds, carbohydrate rich potato, etc. are some of the energy plantation. They may produce energy either by burning directly or by getting converted into burnable gas or may be converted into fuels by fermentation.

2. Petro Crops.

Certain latex containing plants like Euphorbia lathyris (**Grophar or gasoline tree**) and oil palms contain about 5% oil and polymeric hydrocarbons. Highest biocrude potential (10%) lies in resinous species of Compositae family. Calotropis procera (Akra) provides energy on burning comparable to that of **crude oil, fuel**

oil and gasoline.

- Pittosporum resiniferum (petroleum nut) and Botryococcus braunii yield an oily distillate on hydrocracking, 67% of which is diesel oil.
- **Bio-diesel**, an ester based oxygenated fuel is made from vegetable oil. It has low emissions and can be blended in any ratio with petroleum diesel fuel.
- The oily material may be burned in diesel engines directly or may be refined to form gasoline.

3. Agricultural Waste Biomass.

- Crop residues, bagasse (sugar cane residues), coconut shells, cotton stalks, paddy husk etc. produce energy on burning.
- At **Jalkheri, Punjab, a rice straw fired thermal plant** is the only plant of its kind in the world, which will generate **62 million** units of electricity per year.
- **Paddy husk** can be converted into smokeless solid fuel briquettes suitable for use in domestic cooking, kilns and boilers.
- **Rice bran** is used as a source of oil which is converted into methyl ester for use as fuel. **Saw dust,** by partial combustion, is converted into low calorific value **producer gas** for thermal power generation.
- Plant residues along with 500 kg garbage can produce 5 KWH of electricity per hour. The garbage undergoes anaerobic digestion to produce biogas which in turn is used to produce electricity.
- **Jatropha Curcas Linn** belonging to family Euphorbiaceae can be used as a substitute of diesel. **Neem oil**, mahua oil and soya oil can be good blends with diesel.

Environmental Implications.

The burning of coal, oil, wood, dung cakes and petroleum products create well debated environmental hazards. The fly ash requires large ash ponds and smoke causes eye and lung diseases.

• BIOGAS (GREEN ENERGY)

Biogas is a mixture of CH_4, CO_2, H_2, N_2 and H_2S. At 40% methane content, the calorific value of biogas is **3200 kcal/m³** while at 50%, it is 4500 kcal/m^3. Biogas is generated from animal wastes (sometimes plant wastes) in presence of water under anaerobic conditions by mixed population of micro-organisms.

There is a vast reserve of biogas in Indian villages. Biogas plants are mainly of **Floating gas holder type, Fixed dome type** and KVIC type. It is estimated that 1000 million tonnes of animal dung per year is available from 250 million cattle population. On an average, 10 kg of wet dung is available per animal per day, which at 66% collection efficiency, can yield 22500 million cubic metres of biogas through biogas plants. This can replace kerosene oil whereby 14000 million litres of kerosene per year can be saved in villages.

India's Highest Biogas Plant Commissioned at Leh-Ladakh.

Spearheading the effort to tap biogas energy in remote areas, the Defence Institute of High Altitude Research (DIHAR), a constituent laboratory of the Defence Research and Development Organisation (DRDO), has commissioned India's highest (world's second highest) biogas plant at Leh-Ladakh at an altitude of 3500 m amsl in 2010. It has been set up in collaboration with BARC, Mumbai. **The world's highest biogas plant** has been established by **Nepal at Langtang Valley** at 3850 m amsl.

Process. The plant is based on dual process employing partial aerobic

digestion followed by anaerobic digestion. The organically rich biodegradable portion of solid waste (cattle dung, horse and poultry waste) is mixed with recycled water to form a slurry The predigestion of slurry is accentuated by hot water and intermittent aeration. This predigested slurry is further digested under anaerobic conditions for about 15 days followed by methanogenesis in the digester. The capacity of the biogas plant is 0.5 tonne per day and will generate 35 to 50 m^3 of biogas per day during the processing of biodegradable waste. This can be fed to a gas alternator set of 25 kVA capacity to generate electricity or can be used for boiler purposes.

Advantages of using Biogas.

1. Besides being an important domestic energy source, biogas offers an environmentally clean technology.

2. Air-tight digestion of wastes prevent direct exposure to faecal pathogens and parasites.

3. There is direct supply of gas from the plant without any storage problem. 1.5 to 2.1 m^3 of biogas with methane content of 60% is equivalent to 1 litre of diesel in terms of heat output.

4. Biogas slurries can produce 200 million tonnes of organic manure per year which is rich in NPK and iron. It can be utilized in agricultural fields to improve soil fertility and crop productivity.

5. Biogas is not only a fuel for producing green energy but it also reduces green house gases and may qualify for green credits.

• GASOHOL

Gasoline blended with upto 20% methanol or ethanol is known as gasohol. This can be used as a fuel in existing internal combustion engine (ICE). Methanol or ethanol can also be used as fuel (instead of gasoline) in suitably designed ICE. Methanol is produced by destructive distillation of wood. Because of its photosynthetic origin, ethanol is a renewable resource. Ethanol is manufactured by fermentation of sugar resulting from the hydrolysis of cellulose in crop wastes. **Brazil** is the leading country in the manufacture of ethanol for fuel. This country possesses abundant source of fermentable biomass that is, Cassava or manioc.

• HYDROGEN AS AN ALTERNATIVE FUTURE SOURCE OF ENERGY

Hydrogen holds the potential to provide clean, safe, affordable and secure energy from abundant renewable and traditional energy resources.

Attributes of Hydrogen. H_2 is considered as an alternative perfect fuel for two reasons. It is renewable and is the most abundant element (93%) in the universe. Its major reserve (water) is inexhaustible. However, H_2 in nature exists in combination with other elements. For hydrogen to be useful as a fuel, it must exist as free hydrogen.

Production of H_2.

Hydrogen can be produced from a variety of feedstocks including oil, coal, natural gas, biomass and water.

- **From Feedstocks.** H_2 can be produced from coal, residual oil and mainly from natural gas where the efficiency is high and production cost is low.
- **From Biomass.** High temperature is required to convert biomass into H_2 and CO_2.

- **From Water by Electrolysis.** In H_2O, hydrogen is 11.2 percent by weight. H_2 is generated directly by electrolysis of water. Electricity is passed between electrodes immersed in a conducting aqueous solution. H_2 is generated at cathode and O_2 at anode. The energy stored in H_2 can then be reconverted into electricity using the reverse of the electrolytic cell called the fuel cell.

Extraction of Energy from Hydrogen.

1. **By Fuel Cell.** A fuel cell is an electrochemical engine that converts the chemical energy contained in hydrogen molecule into electrical energy. H_2 is oxidised at the cathode where electrons are produced and passed through the circuit to the anode where O_2 is reduced (Fig. 5). The overall efficiency is low due to various energy barriers connected with the electrode processes.

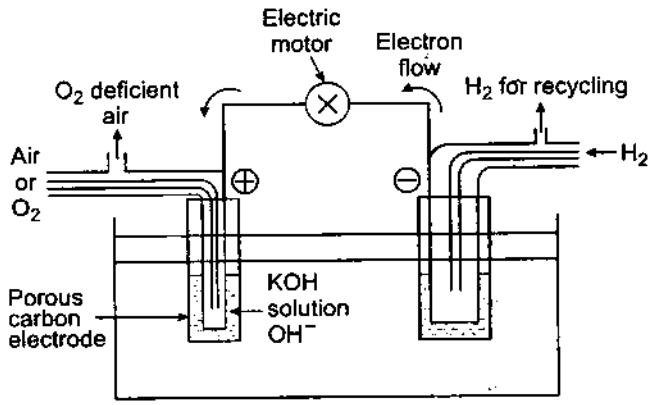


Fig. 5. Production of electricity from hydrogen.

The **proton-exchange membrane** is the most promising fuel cell for automotive use such as light trucks. PEM fuel cell has a low operating temperature and its power density is high for light duty vehicles. The fuel cell coupled with electric drive motors are able to move 18 metric tonne buses efficiently and reliably.

2. Energy contained in hydrogen can also be extracted by simple combustion in internal combustion engines or turbine engines.

Storage of H_2.

Liquid hydrogen storage is preferred to compressed gas storage since more H_2 can be stored in liquid form. Refrigerated and pressurised tanks, based on carbon adsorption system, can store massive amounts of H_2.

Safety. H_2 is highly inflammable and explosive in nature. Safe handling is required for using H_2 as a fuel. H_2 detectors can be used to detect explosive concentrations of hydrogen.

Energy Security.

1. Using hydrogen in conjunction with fuel cells empowers countries to invest in a sustainable energy infra structure.

2. Hydrogen fuel enables individual homes and communities to manage their own energy supply. This reduces dependence on large scale power stations and national grids etc.

3. Hydrogen also supplies more energy per unit volume than diesel or kerosene. Because of its low density, liquid H_2 weighs less than petroleum based fuels. The density of gaseous hydrogen is 0.0899 g/L (air is 1.4 times more dense). Liquid hydrogen boils at –252.77°C and it has a density 70.99 g/L. With these

properties, H_2 has the **highest energy-to-weight ratio** of all fuels. 1 kg of H_2 has the same amount of energy as 2.1 kg of natural gas or 2.8 kg of gasoline.

Environmental Considerations.

- Hydrogen is the cleanest fuel available.
- Hydrogen powered fuel cell vehicles, ICE's; air craft gas turbine engines have zero CO_2 and NO_x emissions.
- H_2, a carbon free perfect fuel, can reduce green house gas emissions.
- To realise environmental benefits of H_2, we must consider the full fuel cycle (also called well-to-wheels) from energy source to hydrogen production to end-use.

Hydrogen Act of 2005 authorises $ 3.2 billion for hydrogen and fuel cell activities intended to enable the commercial introduction of hydrogen fuel cell vehicles by 2020. Thus hydrogen, as energy source holds much promise in future.

• LAND RESOURCES

Land as a Resource.

India has total area of about 329 million hectares. The utilisation statistics available are for nearly 92.5% of the total area. About 162 million hectare of land is under agriculture cover. Nearly 5% of the land falls under fallow land. About 46 million hectare is under real forest as shown by satellites. A part of land is not in use. This waste land includes arid, rocky and sandy deserts. Cities and towns which use much land must grow vertically rather than horizontally. The land is also needed for industry, commerce, transport and recreation. Since total land is a fixed asset, we must take efforts for integrated land use planning.

Land Degradation.

Land is an important component of the life support system. Unfortunately land has been overused and even abused over the centuries. Due to exploding population land is used increasingly which poses threats to its productivity. Careless use damages soil that results into **(i)** reduction in quality of wood land, grassland, cropland, **(ii)** soil erosion, **(iii)** deforestation, **(iv)** degradation of water sheds and catchments. **(v)** Due to demographic pressures land is under stress. Also due to sprawl in agriculture, industry and urbanisation, cropland is degraded and losing fast, fertile top soil.

• SOIL EROSION

Soil erosion is a comprehensive natural process of detachment and removal of loosened soil materials by exogenic processes. It is generally regarded as **creeping death of soil.** Soil erosion is enhanced due to agricultural development, deforestation, flood, overgrazing, construction and strip mining activities. There are numerous physical forces by which the fertile top layer is lost and wasted. **This slow removal of top soil and disturbances in the soil texture is called soil erosion or gravity erosion.**

Nearly 500 to 1000 years are required for the development of an inch of the top layer. But now the problem of erosion is increasing tremendously over the entire globe. The top soil which is thus lost is irreplaceable. Today about 25×10^9 tonnes of precious top soil flows into oceans as silt and sediments every year. India loses about 5300 million tonnes of soil every year. Of this enormous amount nearly 2000 million tonnes get deposited in streams and river beds, 480 million tonnes get lodged in dams and reservoirs and the rest is flushed into the sea. Most of the

reservoirs in India are silting up at a faster rate. This has curtailed the life span of our multipurpose reservoirs drastically. About 30% of world's irrigated cropland is severely affected by salinity and water logging.

Types of Soil Erosion.

1. Normal or Geologic Erosion. This universal erosion is a natural process of denudation that tends to bring the soil to a uniform level. The first phase of this process is weathering which is essentially physico-chemical in nature. Weathering aided by certain biological influences causes disintegration of substances. The process leads to the development of complex soil bodies with definite physical, chemical and biological properties.

2. Accelerated Erosion. It refers to the increased rate of erosion and extreme soil degradation by various land use changes induced by man. There is disequilibrium because of the formation and loss of soil. The fertile layer deteriorate much faster at which new soil forms. Accelerated soil erosion is mostly operative in humid climatic regions where extensive forest clearance, grass land removal and trampling by livestock have been practiced at an alarming rate.

3. Transport Limited Erosion. When the detachment of soil particles equals the transporting capacity of rainfall and run off, it is called transport limited erosion of soil.

4. Detachment Limited Erosion. Here the rate of detachment of soil mass is less than the transport capacity of rainfall.

Agents of Soil Erosion.

The agents which cause soil erosion are classified as follows.

(A) Climatic Agents. Water and wind are the climatic agents of soil erosion.

1. Water Induced Soil Erosion. Water affects soil erosion in the form of torrential rains, rapid flow of water along slopes, run-off, wave action, melting and movement of snow.

Water erodes soil chiefly in **six ways :**

(i) Sheet erosion. When the soil is eroded and removed as a thin covering from large area, it is known as rain wash or sheet erosion.

(ii) Rill erosion. The run off water as rain storms flows rapidly and cuts small stream-like structure in the form of well defined finger shaped grooves.

(iii) Gully erosion. Several rills converge towards the slope and join to form wider and deeper channels of water called gullies.

(iv) Slip erosion. It occurs due to heavy rainfall on slopes of hills and mountains.

(v) Stream bank erosion. The rivers during floods splash their water against the banks and thus cut through them. Water strikes with great speed and the bank caves in alongside.

(vi) Rill and Ravine erosion. It is the most effective form of soil erosion caused by rills and gullies. The heavily gullied and ravinated land is known as **Bad Land.** It is estimated that owing to this erosion, 2.35 million cubic metres of agricultural land are lost every year from Jawa Block of Rewa District of Madhya Pradesh, India.

2. Wind Erosion. Wind erosion occurs in dry (arid) regions where soil is sandy and vegetation is extremely poor. Wind erosion is triggered by the damage of natural vegetation cover of soil by over grazing and over felling. Once the fertile top soil is laid bare to the fury of strong gales it gets blown off in the form of sand or dust

storm and transported to far off places. These rolling particles rub the ground and due to abrassive action help in loosening the top soil. In **India,** wind erosion affects about 50 million hectares of land, most of which is in Rajasthan.

Wind erosion is responsible for the following types of soil movements.

(i) Suspension. Suspension erodes soil in the form of fine dust with the wind.

(ii) Surface creep. The heavier soil particles which are not easily thrown up by wind are simply pushed along the surface by wind.

(iii) Saltation. It occurs in arid regions where drainage is poor, rainfall is low and high temperatures prevail. Salt accumulation occurs around the oceans where water evaporates quickly leaving behind salts containing chlorides, sulphates, carbonates and nitrates of sodium, potassium, magnesium and calcium. The major part of such salty soil is carried away by wind in the form of small heaps.

(B) Biotic Agents. Excessive **grazing, deforestation** and mining are the major biotic agents responsible for soil erosion. Due to these activities the top soil is rendered devoid of vegetation cover. So the land is directly exposed to the action of various physical forces facilitating erosion. Overgrazing accounts for 35% of the world's soil erosion while deforestation is responsible for 30% of the earth's eroded lands. Unsustainable methods of farming cause 28% of soil erosion. Deforestation without reforestation, surface mining without land reclamation, soil compaction by agricultural machinery, excessive irrigation causing salination, water-logged soil, farming on land with unsuitable terrain and cattle trampling etc. make the top soil vulnerable to erosion.

Factors Affecting Soil Erosion.

Food and Agriculture Organization (FAO) have considered the following factors responsible for soil erosion.

(i) Climatic Factors. For example, wind, temperature intensity, energy and rainfall pattern.

(ii) Physiographic Factors. For example, length, steepness, curve of slope.

(iii) Soil Characteristics. For example, aggregation, transportation, detachability and water holding capacity.

(iv) Cover of Vegetation. Forests and cultivation etc. These factors of soil erosion are represented in the form of universal **Soil Loss Equation** as indicated below

$$E = f(C, T, R, V, S, \ldots H)$$

where E is average annual soil/sediment loss

f = function of

C = cropping and management factor

T = Topograply

R = Rock type

V = Vegetation

S = Soil character

H = Human interference.

Detrimental Effects of Soil Erosion.

1. Due to soil erosion Indian subcontinent has faced acute silting problems in **Rihand, Bhakra and other dams.** The life of Bhakra dam is feared to lessen by 250 years due to silt pollution at **Govind Sagar Lake.** Because of this alarming

silt accumulation, it may not last for more than 150 years (constructed to last for 400 years).

2. Soil erosion, salinization and water logging have resulted in a massive loss of 600 million hectares of potential farm lands.

3. **India** has only 2.4% of the land area of the world while CIS has 9.8% and **USA** has 6.7%. But the loss of fertile soil is maximum (18.5%) in India of the total soil loss over the entire planet.

4. The eroded soil is deposited on lakes or river beds and leads to devastating floods.

Control Measures of Soil Erosion.

In a primarily agricultural country like **India** land is by far the most precious asset. We have land about million times more than our all industrial plants and power stations, yet we remain silent spectators to steady destruction of our most valuable resource. **Control measures include following basic principles.**

(i) Protection of soil from the impact of rain fall.

(ii) To increase the infiltration of rain water.

(iii) To prevent water from concentration.

(iv) To encourage more water to enter the soil.

(v) To increase the size of soil particles.

(vi) To increase the soil resistance.

1. **Soil erosion can be controlled** by reducing wind erosion and growing the strips of stubble or other plants. For example, some plants which yield hydrocarbons grow well in arid regions. These include ***Jojoba,*** a plant which produces sap like diesel oil and milky weed. ***Jodhpur Arid Zone Research Institute*** is conducting experiments with such varieties.

2. In overgrazed land fodder trees should be grown like ku-babul, which in irrigated land yield enough green fodder per acre to nourish six cows.

3. Grazing animals should be kept in enclosures.

4. By stubble mulching or trash farming—in which chopped crop residue is spreaded and ploughed into the soil to produce improved tilth in the surface soil

5. By growing intermittent vegetal shelter belts. Surface soil erosion and sand storms leading to sand casting of crop lands can be controlled by creating shelter belts which tend to break the wind and form barriers to check sand movement.

6. By stabilizing sand dunes, *i.e.*, to stabilise the soil in arid regions.

SOIL CONSERVATION PRACTICES.

1. Conservation Till Farming. Here special tillers break up and loosen the sub surface soil without turning over the top soil. The tilling machines make slits in the unploughed soil and inject seeds, fertilizers, herbicides and a little water in the slit. Seeds germinate and a crop grows without competition with weeds.

2. Mechanical Methods. These methods include :

- **Basin listing,** *i.e.*, to built small basins to retain water.
- **Contour terracing,** *i.e.*, to construct a channel along the slope to intercept run off water. Terracing retains water for crops at all levels and cuts down erosion. In heavy rainfall areas, ditches are also provided behind the terrace to permit adequate drainage.

3. Biological Methods, *i.e.*, by growing vegetation.

(a) Agronomic practices. It is the process by which soil erosion is reduced by growing vegetation under natural protection. These are :

- **Crop rotation.** Repeated cultivation of soil depletes the soil nutrients. It can be controlled by cultivating legumes after cereal crops.
- **Strip cropping.** Here strips of crops are alternated with strips of soil saving cover- crops like grasses or grass-legume mixture. Whatever run-off comes from the cropped soil is retained by the strip of cover-crop and this reduces soil erosion.
- **Contour farming.** Field is prepared with alternate furrows and ridges. Ridges of equal level are called contours. Water is caught and held in furrows (small dams) and prevent loss of soil.

(b) Dry land farming. The aim of dry farming is to conserve all the moisture that falls on the land in the form of rain fall. The yields would be high enough to cover the cost of production and make the area self sufficient. Some other methods such as fallowing of land, strip cropping and mulching etc. are also beneficial to check soil erosion.

(c) Agrostological Methods. Grasses like cynodon dactylon which act as stabilizer are grown as erosion-resisting plants. These methods involve lay farming and retiring lands to grass.

4. Other Methods. These methods include :

- **Gully control.** Widening of gullies can be checked by constructing dams, drains or diversions through which excess run off water is channelled.
- **Stream protection.** Vegetation should be grown for cutting the caving of river banks.
- **Wind Breaks or Shelter Belts.** Soil stabilizer trees like Lowsonia alba, Acacia catechu, A. nilotica, Calotropropis gigantea, Zizyphus jujuba, Dalbergia sissoo, Mangifera indica, Tamarindus indica as wind breaker's or shelter belts can be planted in long rows along the cultivated land boundry so that wind is blocked. The wind speed is substantially reduced which helps in preventing wind erosion of soil.

• WATER LOGGING

Farmers usually apply heavy irrigation to their farmlands to provide congenial moisture to the growing crops and to leach down salts deeper into the soil. The accumulated underground water forms a continuous column with the water table. This water logged soil clogs the pore spaces between the soil particles affecting the crop growth due to inhibition of exchange of gases.

Water logging is most often associated with salinity because the water used for irrigation contains salts and the soils get badly degraded due to errorneous irrigation practices. About 1.2 million hectares of land in Haryana has resulted in rise in water table by water logging due to introduction of canal irrigation. **Indira Gandhi Canal Project** of Rajasthan has changed a large area in Western Rajasthan into water logged waste land. It is a startling fact that the cost of development of irrigation projects is very high and in the long run they cause problems of water logging and salinity (loss of Rs. 10,000 million per annum) thereby reducing soil fertility. [Also refer to water logging in Impacts of Modern Agriculture].

DESERTIFICATION.

Desertification is the transformation of fertile land into desert by natural or man made activities. It is caused by erosion of top soil, shifting of sand dunes by wind, mining and over grazing. Desertification is characterized by devegetation and loss of vegetal cover, depletion of ground water, salinization and severe soil erosion. The UNEP estimates suggest that if we do not make sincere efforts, then very soon 63% of range lands, 60% of rainfed croplands and 30% of irrigated farmlands will suffer from desertification on a world wide scale, adding 60,000 km^2 of deserts every year.

• ROLE OF AN INDIVIDUAL IN CONSERVATION OF RESOURCES

Conservation of resources means maintaining the ecological balance without depleting natural resources like water, forest, soil, mineral and energy. An individual can play a vital role in facilitating conservation and regeneration of resources by adopting following strategies.

Conservation of Water.

- Do not keep water taps running while brushing, washing and bathing.
- Install water-saving toilets.
- Check for water leaks in pipes and repair them promptly. A small pin hole sized leak will lead to the wastage of 640 litres of water in a month.
- Water the plants in the evening when evaporation losses are minimum.
- Use drip or sprinkling irrigation to improve irrigation efficiency.
- Install rain water harvesting system in houses which reduces the use of energy and cost for pumping water. One metre of water level saves 0.40 kwh assuming 10 hours of pumping per day for 365 days.

Conservation of Energy.

- Switch off lights, fans and other appliances when not in use.
- Use solar cooker for cooking food on sunny days to cut down LPG consumption.
- Build your house with provision for sun space to keep the house well lit and to save electricity. Houses should be built with proper insulation to avoid heat loss during winters.
- Grow deciduous trees outside the houses to cut off intense heat of summers and to get a cool breeze. This will reduce electricity charges on coolers and air conditioners. A big tree is estimated to have a cooling effect equivalent to five air conditioners. Deciduous trees shed their leaves in winter. So they do not create any hindrance to sunlight and heat.
- Drive less, make fewer trips, join a car pool or use public transportation wherever possible to save petrol or diesel.
- Use renewable energy resources which are inexhaustible and can be harvested continuously through a sustained proper planning.
- Recycle and reuse paper, glass, metals and plastic.

Conservation of Soil.

- Grow different types of ornamental plants, herbs and trees in the garden.
- Make compost from the vegetable peelings and the kitchen waste.
- Avoid over-irrigation of agricultural fields to prevent water logging and salinization.
- Use mixed cropping and crop rotation so that some specific soil nutrients do not get depleted.
- Use green manure and mulch in the fields to maintain soil fertility.

Promote Sustainable Agriculture.

- Fertilize your crop primarily with organic fertilizers.
- Achieve pest control biologically instead of using pesticides. Neem based insecticides hold promise as an ecofriendly substitute.
- Use drip irrigation to water the crops.
- Eat local and seasonal vegetables and fruits. This saves lot of energy on transport, storage and preservation.

• EQUITABLE USE OF RESOURCES FOR SUSTAINABLE LIFE STYLE

There is a great variation in the population and **utilization of natural resources** among different countries. The more developed countries (MDC's) represent only 22% of world population but consume 88% of natural resources and about 80% of the global energy. MDC's include USA, Canada, Japan, CIS, Australia, New Zealand and Western European countries. The less developed countries (LDS's) on the other hand represent 78% of the world's population and use only 12% of natural resources and 20% of the global energy.

The **rich nations** are contributing more to pollution and threatening the sustainability of life support systems on the earth. The **poor nations** are still struggling hard with their huge populations and poverty problems. The rich have grown richer while the poor have gone even poorer. This needs equal distribution of resources especially the basic requirements like drinking water, food and fuel etc. so that people in LDC's are at least able to sustain their life. The problems of LDC's like pollution, unhygienic conditions, diseases etc. can be brought under control only with the help of MDC's.

In order to achieve sustainable life styles it is desirable to achieve a more balanced and equitable distribution of global resources and income to meet every one's basic needs. The rich nations will have to reduce their consumption levels and divert some resources to the poor nations. A fairer sharing of resources will narrow down the gap between the rich and the poor and will lead to sustainable development for all and not just for a privileged group.

• BIODIVERSITY AND ITS CONSERVATION

INTRODUCTION

Biodiversity refers to the wide variety of life forms on earth and the ecosystem complexes in which they occur. The biosphere comprises of a complex collection of innumerable organisms, known as biodiversity which constitutes the vital life support for the survival of human race. In the convention of Biological diversity signed at **Rio de Janeiro Brazil in 1992 by 172 nations, the Biological diversity is defined as the variability among living organisms from all sources including interalia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part. This includes diversity within species, between species and ecosystems.**

Biological diversity (or biodiversity) represents the sum total of various life forms such as unicellular fungi, bacteria, protozoa and multicellular organisms such as plants, fishes, birds and mammals at various biological levels including genes, species, habitats and ecosystems. Our biological systems are constantly impoverished by human activities. Only the man is responsible for the destruction of habitats through intensive agricultural development, urbanisation, industrialisation, over population, deforestation, exploitation of resources and ethical degradation etc. Thus strategies must be developed and implemented for the preservation, maintenance and restoration of forest ecosystems while

simultaneously formulating action plan for the sustainable use of forest resources including efficient utilisation, recycling techniques and reforestation.

• LEVELS OF BIODIVERSITY

Units of biodiversity may range from the genetic level within a species to the biota in a specific region and may extend upto the great diversity found in different biomes.

1. Genetic Diversity (Diversity of Genetic Organisation within a Species).

There exists several varieties within any given species which slightly differ from each other in one or more characteristics such as shape, size, resistance against insects, pests, diseases and resilience to survive under adverse environmental conditions. Such a diversity in the genetic make up of a species is known as genetic diversity. When the genes within the same species show different versions due to new combinations, it is called genetic variability. A species having large number of varieties, strains or races is considered as rich and more diverse in its genetic organisation.

2. Species Diversity (Diversity of Species within a Community).

The richness of species in an ecosystem is called species diversity. The biotic component of an ecosystem may be composed of a number of species of plants, animals and microbes which interact with each other and also interact with the abiotic factors of the environment. Species diversity can be measured by **popular indices known as Shannon-Weiner** index and **Simpson index**. Current estimates (2010) indicate that about 10 to 80 million species exist on earth. However, only 1.5 million living species have been assessed and enlisted so far. We have been losing this accumulated heritage by our own activities, thereby undermining the very basis of our own existence.

3. Biotic Community and Ecosystem Diversity.

This is the diversity of ecological complexity showing variations in ecological niches, trophic structures, functions, food webs and nutrient cycling etc. An ecosystem develops its own characteristic community of living organisms depending upon the availability of abiotic resources, environmental conditions like moisture, temperature, altitude and precipitation etc. Different types of forests, grass lands, meadows, rivers, lakes, ponds etc. represent diverse ecosystem with their own characteristic biotic community. For example, a pond may possess different sets of flora and fauna as compared to another ecosystem such as river.

4. Landscape Diversity.

It refers to the placement, size and distribution of various ecosystems and their interactions across a given land surface.

• BIOGEOGRAPHICAL CLASSIFICATION OF INDIA

India has different types of climate and topography in different parts of the country and these variations have induced enormous varieties of flora and fauna. India has a rich heritage of biological diversity and occupies the **tenth position** among plant rich nations of the world. **Biogeography** comprising of phytogeography and zoogeography deals with the various aspects like evolution, distribution, dispersal and environmental relationship of plants and animals. In order to gain insight about the distribution and environmental interactions of flora and fauna of India, it has been classified into **ten biogeographic zones** (Table 1).

Table 1. India's major biogeographic habitats.

S. No.	Biogeographic zone	Biotic province	Total area (sq. km.)	Important flora and fauna
1.	Trans-Himalayan	Upper regions	1,86,200	Pine, deodar, yak, Tibetian ass, snow leopard, wolf, wild sheep, marmot, crane.
2.	Himalayan	North-West Himalayas	6,900	Pine, cork tree, dhaak, castor, sal, wild bear, sambar, musk deer, leopard, Sikkim stag
		West Himalayas	7,20,000	
		Central Himalayas	1,23,000	
		East Himalayas	83,000	
3.	Western ghats	Malabar Coast	59,700	Tuna, bahera, peepal, sheesham
		Western ghat mountains	99,300	Frog, snakes, tortoise, lizards
4.	Desert	Kutch	45,000	Acacia, Khejri, Zizyphus, date palm
		Thar Ladakh	1,80,000	Camel, bastard, desert cat, fox, rat, wild ass
5.	Semi-arid	Central India	1,07,600	Acacia, peepal, date palm
		Gujarat Rajwara	4,00,400	Sariska and Ranthambore (Tiger reserves)
6.	North-East India	Brahmaputra valley	65,200	Sal, bamboo, castor, chestnut
		North-eastern hills	1,06,200	Rhinoceros, yak, deer, porcupine
7.	Deccan peninsula	South plateau	3,78,000	Acacia, tuna, pine, castor
		Central plateau	3,41,000	Sambar, sloth bear, cheetal
		Eastern plateau	1,98,000	Four-horned stag
		Chhota Nagpur	2,17,000	Wild elephant
		Central highlands	2,87,000	Wild buffalo
8.	Gangetic plain	Upper plain	2,06,400	Sal, acacia, mango, bel, jamun
		Lower plain	1,53,000	Black chinkara, alligator, turtle
9.	Islands	Andaman	6,397	Harar, bahera, cardamom
		Nicobar	1,930	Coconut, cloves
		Lakshadweep	180	Dolphin, alligator, molluscs
10.	Coasts	West coast	6,500	Banana, coconut, cashew nut
		East coast	6,500	Dugong, dolphin, turtle

Source. Conserving our Biological Wealth. WWF for Nature—India and Zoological Survey of India.

Each of these zones has its own characteristic climate, soil, topography and biodiversity.

• VALUES OF BIODIVERSITY

A rich biodiversity is essential for the sustainable biosphere and bio-industrial development of a country. The multiple uses of biodiversity are listed below.

1. Consumptive Use Value.

Biodiversity provides us valuable natural resources to satisfy the subtle needs of mankind. Our homes, livestock, fruits, vegetables, grains, grams etc. are all derived from the products of diverse and healthy ecosystems. Food, drugs, fibre, shelter and a host of other useful products are obtained from a variety of living organisms.

(i) Food. A large number of edible plant species are consumed by man as food. About 90% of the modern food crops have been domesticated from wild tropical plants. Even now agricultural scientists make use of the existing wild species of plants for developing better strains.

(ii) Drugs and Medicines.

- About 75% of the pharmaceutical life saving drugs are of plant origin. **Reserpine** (hypertension) is obtained from Rauwolfia serpentina, **quinine** (malaria) is derived from Cinchona ledgeriana, **morphine** (analgesic) is yielded by Papaver somniferum, **taxol (anticancer drug)** is obtained from the bark of yew tree (Taxus baccata and Taxus brevifolia), **vinblastin** and **vincristine** drugs (containing anticancer alkaloid) are derived from Periwinkle (Catharanthus) plant.
- The wonder drug **Penicillin** used as antibiotic is derived from a fungus Penicillium. **Digitalin** is obtained from foxglove (Digitalis) which is effective for heart ailments.
- Bee sting venom is used for treating arthritis. The Peepal tree leaves, roots, trunks are used for curing fever, cough, skin diseases etc. A plant found in west Africa, called **Katemfe** (Thaumatococcus danielli), produces proteins that are 1600 times sweeter than sucrose. Several plant species, having other potential medicinal applications, are yet to be screened and intensively studied for their applications.

2. Genetic Resources.

Biological diversity represents a valuable **genetic resource** for the mankind. However, for getting better strains in future, it is essential to build up a gene-pool containing an assortment of traits. The quality, yield and resistance to pests, diseases and adverse climatic vagaries mostly depend on genetic factors and combination of genes which may be different in different varieties of species. Improved varieties containing higher number of useful traits and **desirable gene combinations** are always preferred which are more **productive** and have better adoptability. There are several examples to illustrate how genetic modification helped in improved quality and pest-resistance of the product.

- *The Kans grass known as Saccharum spontaneum from Indonesia provided genes for resistance to red rot disease of sugar cane.*
- *A wild variety of rice grown in U.P. saved millions of hectares of paddy crop from Grossy Stunt virus.*
- *The genes from a wild melon grown in U.P. helped in imparting resistance to powdery mildew in musk melons grown in California.*
- *About 20 cultivars of rice grown in several countries were benefited from the useful genes identified from wild varieties from Kerala.*

The vast pool of **genetic diversity** contained within wild populations of plants and animals is of enormous value of the continuing research and development of agriculture, industry and medicine.

3. Productive Use Value.

Many industries like textile industry, plywood industry, ivory industry, pulp and paper industry depend upon the productive value of biodiversity. Animal products such as tusks of elephants, musk from deer, silk from silk worm, wool from sheeps, fur and lac etc., are traded in the market. Developing countries in Asia, Africa, Latin America are the richest biodiversity centres. Despite ban on trade, wild life products (fur, hide, horns, tusks, live specimens) are smuggled and marketed in large quantities to some rich western countries and also to China and Hong Kong where export of cat skins and snake skins fetches a booming business.

4. Social Value.

Biodiversity has distinct social value related to our cultural, religious and spiritual aspects. Plants and animals are considered as the symbols of national pride and cultural heritage. Many plants like Tulsi, Peepal, Mango, Lotus, Bael, Khejri are regarded holy, sacred and worshipped in our country. The social life of the tribal people (their songs, dances, customs) are closely woven around the wildlife in the forests. Many animals like cow, snake, bull, peacock, owl etc. have significant place in our psycho-spiritual arena and thus hold special social importance.

5. Ethical Value (or Existence Value).

It involves ethical issues like **all life must be preserved.** It is based on the concept of Live and Let Live. If we want human race to survive, then we must protect all biodiversity. Ethical value means that we may or may not use a species but its existence in nature gives as pleasure. We all feel sorry when we know that dodo or passenger pigeon is no more on this earth. We are not deriving anything direct from zebra, kangaroo or lion but we strongly feel that these species should survive in nature. This indicates the ethical value attached to each species.

6. Aesthetic Value.

Eco-tourism, bird watching, wildlife, pet keeping, gardening etc. provide aesthetic rewards of biodiversity. The **willingness to pay** concept on eco-tourism gives us even a monetary estimate for its aesthetic value. Eco-tourism is estimated to generate about 12 billion dollars of revenue annually that roughly gives the aesthetic value of biodiversity. For instance,

- A male lion can generate upto $ 515.000 due to its aesthetic value as paid by tourists, whereas if killed for the lion skin, a market price of $ 1000 can be fetched.
- A Kenyan elephant can earn worth $ 1 million as tourist revenue.
- The mountain gorillas in Rwanda are fetching $ 4 million annually through eco-tourism.
- Whale watching on Hervey Bay on Queensland coast earns $ 12 million per year.
- Tourism to Great Barrier Reef in Australia earns $ 2 billion annually.
- A typical tree provides $ 198,2150 worth of ecological services, whereas its value is only $ 600 if sold as timber.

7. Option Value.

Option values include the potentials of biodiversity that are presently unknown and need to be explored. There is a possibility that we may have some potential cure for cancer or AIDS existing within the depth of a marine ecosystem or in a tropical rain forest. Thus option value suggests that there are biological resources existing on this biosphere that may prove to be miracle species in future. Option value of biodiversity also includes areas where a variety of flora and fauna or specifically some endemic, rare or endangered species exist. Biodiversity is the precious gift of nature presented to us. We should not commit the folly of losing these gifts before unwrapping them.

8. Ecosystem Service Values.

Recently, a non-consumptive use value related to self maintenance of the ecosystem and various important ecosystem services has been recognised. Diverse communities of plants, animals and micro-organisms provide us indispensable ecological services. They recycle wastes, maintain the chemical composition of the atmosphere and play a major role in determining the climate. The **ecosystem**

services provide to us by nature in **gratis** also include supply of fresh water, maintenance of soil fertility, cycling of nutrients, fixation of nitrogen, pollutant absorption, supply of plant pollinators and maintaining a huge **genetic library.**

• GLOBAL BIODIVERSITY

Globally, about 1.5 million species are known till date which is perhaps 2% of the actual number. We have roughly 170,000 flowering plants, 30,000 vertebrates, about 250,000 other groups of species and the remaining species may range from 8 million to 100 million. Table 2 illustrates the estimated number of some known living species (1,400,000) in different taxonomic groups.

Table 2. Living species estimates (World Resource Institute, 1999).

Taxonomic group	Number of species	Taxonomic group	Number of species
Bacteria	5,000	Snails, clams, slugs	70,000
Protozoans	31,000	Insects	7,50,000
Algae	27,000	Mites, cockroaches, ticks	1,20,000
Fungi (Mushrooms, molds)	45,000	Fish and sharks	22,000
Higher plants	2,50,000	Amphibians	4,000
Sponges	5,000	Reptiles	5,000
Jelly fish, corals	10,000	Birds	9,000
Earthworms, flatworms	36,000	Mammals	4,000

Terrestrial biodiversity of earth is best described as **biomes.** Biomes are the largest ecological units present in different geographic areas and are named after the dominant vegetation, *e.g.*, the tropical rain forests, coniferous, deciduous forests, savannas, desert, tundra etc. **The tropical rain forests** constitute about 50% to 80% of global biodiversity and are inhabited by teeming millions of species of plants, birds, insects, amphibians and mammals. They are the earth's largest store house of biodiversity. More than one-third of the world's therapeutic drugs are extracted from plants growing in tropical forest.

Out of the 3,000 plants identified by National Cancer Research Institute as sources of cancer fighting drugs 70% come from tropical rain forests. Very recently, extract from one of the creeping vines in the rain forest at Cameroon has proved effective in the inhibition of replication of AIDS virus. The wonderful Neem tree known for its medicinal properties in tropical India, has now come into lime light even in the western temperate countries. Euphorbia lathyris **(Grophar or gasoline tree),** the most suitable energy plant, contains more than 5% oil and polymeric hydrocarbons. Tropical forests having 1,25.000 flowering plants are the treasure houses of food, medicine and commerce. Tropical deforestation alone is reducing the biodiversity by half a percent every year. Several species are becoming extinct before they have been discovered. The **Silent Valley** in Kerala is the only place in India where tropical rain forests occur. Needless to say, we must protect our precious forests. The case of Silent Valley Hydroelectric Project was abandoned mainly because it had put to risk our tropical rain forest biodiversity. Temperate forests have much less biodiversity but there is much better documentation of species.

Marine diversity is even much higher than terrestrial biodiversity and ironically, they are still less known. Estuaries, coastal waters and oceans are biologically diverse and the diversity is just dazzling. Sea is the cradle of every

known animal phylum. Out of the 35 existing phyla of multicellular animals, 34 are marine and 16 of these are exclusively marine.

Mapping the biodiversity has therefore, been rightly recognized as an emergency matter in order to plan its conservation and practical utilization in a judicious manner.

• NATIONAL BIODIVERSITY : INDIA AS A MEGA-DIVERSITY NATION

India is one of the **12 mega-diversity** countries in the world. It ranks **10th** among the plant rich countries, **11th** in terms of endemic species of higher vertebrates and **6th** among centres of diversity and origin of agricultural crops. The Ministry of Environment and Forests, Government of India currently recorded 47,000 species of plants and 81,000 species of animals which is about 7% and 6.5% of global flora and fauna.

Table 3. Distribution of species in major taxonomic groups of flora and fauna in India.

Plant's group	Number of species	Animal's group	Number of species
Bacteria	850	Mollusca	5042
Algae	2500	Arthropods	57525
Fungi	23000	Pisces (Fishes)	2545
Bryophytes	2564	Amphibia	204
Pteridophytes	1022	Reptiles	428
Gymnosperms	64	Birds	1228
Angiosperms	15000	Mammals	372

Note that :

- India is unique in having immense natural beauty in its different biomes and in possessing a diverse flora and fauna.
- Indian wildlife is incomparable in its variety. The tiger, lion, leopard, elephant, rhinoceros, snakes and minks are found here in abundance. India has more graceful deers, peacocks and cats than any other country in the world.
- India includes more than **150 families of terrestrial vertebrates** and more than 7,50,000 species of insects.
- The **animals** like black buck, Nilgiri tahr, pigmy hog, golden langur, lion-tailed macaque etc., are unique wild animals of India. India is gifted with a wide variety of deers such as musk deer (Kastura), barking deer, spotted deer (Cheetal), swawp deer (Bara singha), hog deer, mouse deer and dancing deer (Sambhar).
- The typical wild Indian **birds** include peafowl, jungle fowl, quail, duck, pigeon, sand grouse, eagle, pelican, hornbill etc.
- Indian **reptiles** include crocodiles, lizards, gharials and more than 125 varieties of snakes.

Many wild animals have disappeared due to natural and human activities. About 600 species of animals and birds have become extinct because of climatic and geographic changes and also by over hunting by man for food, fur, recreation and monetary benefits.

Endemism (species restricted only to a particular area). About 62% of amphibians and 50% of lizards are endemic to India. Western ghats exhibit the site of maximum endemism. [Also refer to Endemic species of India in the same unit].

Centre of origin. India has been the centre of origin of 5000 species of flowering plants, 166 species of crop plants and 320 species of wild varieties of cultivated crops, thereby providing a broad spectrum of diversity of traits for crop plants.

Marine diversity. In India, marine diversity is rich in molluscs, crustaceans, corals, polychaetes, mangrove plants and sea grasses. More than 350 species of corals of the world are found here. India has **two hot spots of biodiversity** (out of 25) in north-east region and western ghats. However, a large proportion of biodiversity (93 major wetlands, coral reefs and mangroves) is still to be fully explored.

• LOCAL OR REGIONAL BIODIVERSITY

Biodiversity at regional level can be categorized into three types based upon their spatial distribution.

1. Alpha Diversity. Alpha diversity indicates **diversity within the community.** It refers to the diversity of organisms sharing the same community or habitat in a small homogeneous area. Alpha diversity is strongly correlated with physical environmental variables. For example, there are 100 species of tunicates in arctic waters, 400 species in temperate waters and 600 species in tropical seas. Thus, temperature seems to be the most important factor affecting alpha richness of tunicates.

2. Beta Diversity. Beta diversity indicates **diversity between communities** across different habitats and environmental gradients. Beta richness means that the cumulative number of species increases as more heterogeneous habitats are taken into consideration. For example, the ant species found in the local regions of north pole is merely 10. As we keep on moving towards the equator and add more and more habitats, the number of ant species reaches as high as 2000 on the equatorial region.

3. Gamma Diversity. Gamma diversity refers to the diversity of habitats over the total landscape gradients or geographical area. The diverse communities are functionally more productive and stable even under environmental stresses.

• HOT SPOTS OF BIODIVERSITY

Hot spots of biodiversity are the areas which exhibit high species richness and exceptional concentration of species endemism. Hot spots are the most threatened reservoir of plant and animal life on earth. The term was first introduced by **Norman Myers** in 1988. There are **25 such hot spots on a global level** out of which two are present in India, namely the Eastern Himalayas and Western Ghats (Table 4). Fifteen hot spots occur in tropical forests, five are Mediterranean type and five are islands. These hot spots covering 1.4% of the total world's land area are found to exhibit 40% of terrestrial plants and 25% of vertebrate species. After the tropical rain forests, the second highest number of endemic plant species are found in the Mediterranean (Mittermeier).

Broadly, these hot spots are in Western Amazon, Madagascar, Borneo, North-Eastern Australia, West Africa, Brazil's Atlantic forests, Arctic Tundra, Alaska, Mauritius and Alps. About 1/6th of the world's population, most of whom are desperately poor people, live in these areas. Any measure of protecting these hot spots need to be planned keeping in view the human settlements and tribal issues.

Table 4. Global hot spots of biodiversity.

S. No.	Hot spots	Plant species	Endemic plants	% of Global plants	Verte-brate species	Endemic verte-brates	% of Global verte-brates
1.	Tropical Andes	45,000	20,000	6.7	3,389	1,567	5.7
2.	Caribbean	12,000	7,000	2.3	1,518	779	2.9
3.	Brazil's Atlantic Forest	20,000	8,000	2.7	1,361	567	2.1
4.	Madagascar	12,000	9,704	3.2	987	771	2.8
5.	Western African Forests	9,000	2,250	0.8	1,320	270	1.0
6.	Cape Floristic Province	8,200	5,682	1.9	562	53	0.2
7.	Mediterranean Basin	25,000	13,000	4.3	770	235	0.9
8.	Succulent Karoo	4,849	1,940	0.6	472	45	0.2
9.	Philippines	7,620	5,832	1.9	1,093	518	1.9
10.	South Central China	12,000	3,500	1.2	1,141	178	0.7
11.	New Caledonia	3,332	2,551	0.9	190	84	0.3
12.	New Zealand	2,300	1,865	0.6	217	136	0.5
13.	California Floristic Province	4,426	2,125	0.7	584	71	0.3
14.	Indo Burma Eastern Himalayas	13,500	7,000	2.3	2,185	528	1.9
15.	Western Ghats—Sri Lanka	4,780	2,180	0.7	1,073	355	1.3

Source. Myers *et al.*, 2000.

Hot Spots of India.

Hot spots of India are not only rich in floral wealth and endemic species of plants but also exhibit diversity among amphibians, reptiles, tailed butterflies and some mammals. Two out of 25 hot spots lie in India extending into neighbouring countries namely, Indo-Burma region (covering Eastern Himalayas) and Western Ghats—Sri Lanka region.

(A) Eastern Himalayas. Eastern Himalayas display an ultra-varied topography that fosters species diversity and endemism. There are numerous deep valleys in Sikkim which are extremely rich in endemic species. In an area of 7298 km^2 of Sikkim, about 4300 plant species are found of which 60% are endemic. The **North-East India** alongwith its contiguous regions of Burma and Chinese provinces of Yunnan and Schezwan is considered as the **cradle of flowering plants.** Out of the world's recorded flora, 33% are endemic to India of which 35,100 are in the Himalayas. Now forest cover of Eastern Himalayas has dwindled to 1/3 of its original arena. Certain species like Sapria himalayana, a parasitic angiosperm was seen rarely in the last 50 years.

(B) Western Ghats. Western Ghat extends along a 17,000 km^2 strip of forests in Tamil Nadu, Kerala, Karnataka and Maharashtra and has 40% of the total endemic plant species. About 50% lizards and 62% amphibians are endemic to Western Ghats. The major centres of evergreen diversity are **Agastyamalai Hills** and **Silent Valley**—the new Amambalam Reserve Basin. It is reported that only 6.8% of the original forests are existing today while the rest has been deforested.

Although the hot spots are characterized by endemism, yet a few species are common to both the hot spots in India. Common plants include Hypericum, Rhododendron, Ternstroemia japonica while the common fauna includes Fairy blue bird, laughing thrush and lizard hawk etc. **Other hot spots of India** facing threat to endemic species include Silent Valley (Kerala), Palni and Nilgiri hills (Tamil Nadu), Kodai and Ooti lake (Tamil Nadu), Doon Valley (Uttaranchal), Chilka lake (Orissa), Narayan Sarovar (Gujarat), Sunderbans (West Bengal), Thar desert (Rajasthan), Dal lake (Kashmir), Gir forest and little Rann of Kachch (Gujarat), wet land and Sariska (Rajasthan).

The hot spot approach has been valuable in enabling nations to better target their conservation investments. Efforts are underway to identify hot spot areas of other ecosystems including wetlands, deserts and large lakes.

• THREATS TO BIODIVERSITY

Over the past few decades, the rate of global loss of biodiversity and the consequent biotic impoverishment has been increasing alarmingly. The rate of extinction of species (10,000 species per year) has escalated more dramatically. The important factors responsible for the loss of biodiversity are described below.

1. Habitat Loss.

Exponential growth in human population and the consequent growth in consumption of world's natural resources have led to the accelerated loss of species and habitats. Billions of hectares of forests have been converted into agricultural lands, settlement areas, dams, reservoirs or development projects. Recent tropical deforestation is associated with a pervasive cycle of initial timber extraction, followed by shifting cultivation, land acquisition and subsequent conversion to pasture which leads to loss of forest resources and reduction in biodiversity. **Migratory birds** are also affected by deforestation. The **California condor** (Cathartes californianus), a shy scavanger and **largest flying bird** of today has disappeared due to loss of food and habitat.

The unique rich biodiversity of **wetlands, estuaries and mangroves** is lost due to draining, filling and pollution. Massive destruction of mangroves in Asia, West Africa, Costa rica and Philippines have resulted in extensive damage to fish productivity and highly productive coral reefs apart from erosion of coast line. Marine biodiversity is also under serious threat owing to large scale destruction of the fragile breeding and feeding grounds of our oceanic fish as a result of human intervention.

2. Habitat Fragmentation.

Here the loss of habitat is in instalments so that the habitat is divided into small and scattered patches or fragments. Many wildlife species like bears and large cats get badly threatened as they breed only in the interiors of the forests.

3. Poaching of Wildlife.

Illegal trade of wildlife products by killing prohibited endangered animals, *i.e.*, poaching is another threat to wildlife. Despite international ban on trade in products from endangered species, smuggling of wildlife items like furs, horns, tusks, hides, live specimens and herbs worth millions of dollars per year continues. Poachers make huge money through smuggling them to other countries. The cost of elephant tusks can be $ 100 per kg; the fur coat is sold at $ 100,000 in Japan while a beautiful bird—a rare hyacinth **macaw** from Brazil can fetch upto $ 10,000. So we must realize that **wildlife** is not just a game to be hunted for money, rather it **is a gift of nature to be nurtured and enjoyed**.

4. Natural Upheavals.

Natural calamities such as earth quakes, floods, volcanic eruptions, forest fires, epidemics, droughts, etc., cause extensive damage to plant and animal diversity.

5. Environmental Pollution.

Pollutants such as pesticides, chlorinated hydrocarbons and toxic heavy metals destroy the weak and susceptible species and damage the living organisms. Over-fertilization leads to eutrophication which promotes the growth of some species while suppressing others. Industries emitting SO_2 and NO_x cause acid rains which destory plants, animals and fishes.

6. Invasion by Exotic Species.

Any species which is not a natural inhabitant of the local habitat but is introduced into the system accidently or deliberately, is called ***exotic species.*** Several instances are known when a natural biotic community of the ecosystem suffered extensive damage because of the invasion by exotic species. **A classical example** is the contamination of wheat seeds imported by us from USA under PL-480 scheme by *parthenium hysterophorus* (known as congress grass) and *Agrosteamma githago* (known as corn cockle). Both the species grew and spread all over the country as pernicious weeds in wheat fields. Parthenium is an aggressive plant which matures rapidly and generates thousands of seeds. Because of these plants, indigenous herbs and grasses as well as cultivated crops suffered as it depletes the nutrients from the soil. Moreover, the enormous quantity of pollens produced by parthenium cause allelophatic effects on cultivated plants like tomato, chillies, brinjals and inhibited their growth.

Similarly, myrtaceae (eucalyptus) and casurinaceae (casurina) are the species introduced from Australia and Tropical America into our country. Their extremely fast growth made them a valuable source of rough timber. However, they tend to suppress the native inhabitants and hence are ecologically harmful. Another striking example is the introduction of **Nile perch** from north in Lake Victoria in Africa, because of which about 50% of the 400 original fish species of the lake were driven to near extinction.

7. Over-exploitation of Selected Species.

Man used over 5000 species and varieties of edible plants for his sustenance. Now, several traditional varieties are neglected and only about 150 species of plants are cultivated on large scale.

8. Loss of Medicinal Plants.

Over-exploitation of certain types of species is leading to dwindling of some plants of scientific, medical, decorative and other values. Medicinal plants such as podophyllum species are fastly disappearing due to huge collection. Similarly timber-producing trees of economic value such as Dysoxylon malabaricum, santalum album, pterocarpus santalum and orchids producing decorative flowers are diminishing due to over-exploitation.

9. Cultivation of Limited Species.

Further, only limited varieties of rice, wheat, corn, apples, potatoes etc. are widely cultivated today, neglecting totally the traditional varieties. Hybrid varieties have replaced old strains of wheat and rice to obtain higher yields. Such a reduction of genetic diversity among the cultivated species and disappearance of their wild relatives, may restrict the creation of new cultivars in future, which does not augur well for the posterity.

10. Hunting.

Elephants, tigers, rhinoceros, snakes, crocodiles, whales, minks and birds are mercilessly hunted for food, recreation, and monetory benefits from their horns, tusks, hides, skins etc. Many species of fishes, sea turtles, sea cows and whales are facing extinction.

11. Climatic Changes.

Increasing concentration of green house gases may cause extensive changes in environmental conditions and precipitation patterns which may endanger the plant species as a whole. Since different species respond to changing climatic patterns in different ways, the entire global biotic spectrum will change and in such a sweeping upheaval, the biological diversity is likely to be drastically reduced. The species in the Boreal coniferous forests at the northern belt skirting the Arctic sea are getting reduced due to harsh and unfavourable climatic conditions.

• MANWILDLIFE CONFLICTS

Sometimes wildlife causes immense damage and danger to man creating conflicting situations between man and animal. Instances indicate that in Sambalpur, Orissa 195 men were killed by elephants in the last five years. In retaliation, the villagers killed 98 elephants and badly injured 30 elephants either by electrocution or hiding expolsive in their fields. Recently in 2008, a man-eating tiger killed 16 people in the Royal Chitwan National Park, 240 km southwest of Kathmandu. The park renowned for its wildlife conservation effort has become a zone of terror for the local residents. Such conflicting situations are often reported from the border regions of Corbett, Dudhwa, Palamau and Ranthambore National Parks in India.

Causes of Man-Animal Conflicts.

- Dwindling habitats of wild animals due to shrinking forest cover compels them to move out the forest and attack the field or man.
- Human encroachment into the forest areas raises a conflict between man and animal, perhaps because it is an issue of survival of both.
- Usually the ill, weak, injured and man-eater animals have a tendency to attack human beings.
- When there is shortage of staple food for wild animals in sanctuaries and national parks, they move out in search of food and cause massive damage to crops.
- Very often, the villagers put electric wiring around their ripe crop fields. The animals get injured, suffer in pain and turn violent.
- Due to the development of human settlements in the wildlife corridors, their path has been disrupted and the animals attack man.
- The cash compensation paid by the government in lieu of the damage caused to the farmer's crop is not sufficient. The agonized farmers get revengeful and kill the animals.

Remedial Measures to Curb the Conflict.

- Cropping pattern should be changed near the forest borders. Adequate fodder, fruit and water should be made available for the wild animals within forest zones.
- Solar powered fencing should be provided along with current proof trenches to prevent animals from straying into the fields.
- Wildlife corridors should be provided for mass migration of big animals during unfavourable periods.

- **Tiger Conservation Project (TCP)** has made provisions for making available vehicles, binoculars, tranquilizer guns, radio sets etc. to tactfully deal with any imminent danger.
- The government should provide adequate compensation to the farmers for the crops damaged by wild animals.
- In Similipal sanctuary, Orissa there is a ritual of wild animal hunting during April-May for which forest is burnt to flush out the animals. Due to massive hunting by people, there is a decline in prey of tigers and they start coming out of the forest in search of prey. Now there is **WWF-TCP** initiative to curb this ritual of Akhand Shikar in Orissa.

• ENDANGERED SPECIES OF PLANTS AND ANIMALS

The **World Conservation Union**, formerly known as International Union for Conservation of Nature and Natural Resources (IUCN) has published the **Red Data Book** which includes the list of endangered species of plants and animals. The red data symbolizes the warning signal for those species which are endangered and if not protected are likely to become extinct in near future. The 2000 IUCN Red List categorises the species according to which they face the extent of extinction.

A species is said to be

(i) Extinct when it is not seen in the wild for 50 years, *e.g.*, Dodo, passenger pigeon.

(ii) Endangered when its number has been reduced to a critical level or whose habitats have been reduced drastically. If such a species is not protected and conserved, it is in immediate danger of extinction.

(iii) Vulnerable if its population is facing continuous decline due to over exploitation of habitat destruction.

(iv) Rare which are not endangered or vulnerable at present but are at a risk. These taxa are usually endemic or thinly scattered over a more extensive area.

Status of Endangered Species.

Presently, the 2000 Red List contains more than 18000 species out of which 11096 species (5611 plants and 5485 animals) are threatened. About 1939 species (1014 plants and 925 animals) are assessed as critically endangered. Globally, the percentage of major groups of organisms (angiosperms, amphibians, reptiles, birds and mammals) is evaluated as : 9-16% species are critically endangered, 17-22% are endangered and 34-51% are vulnerable. A few species of **endangered animals and plants** in India are illustrated below.

1. Reptiles. Python, Gharial, Green sea turtle, Tortoise.

2. Birds. Great Indian bustard, Peacock, Pelican, Siberian white crane, Spotted owl, Hornbill.

3. Carnivorous mammals. Indian wolf, Red panda, Tiger, Leopard, Indian lion, Red fox, Golden cat, Striped hyena, Dugong.

4. Primates. Hoolock gibbon, Lion-tailed macaque, Nilgiri langur, Golden monkey and Capped monkey.

5. Plants. Orchids, Rhododendrons, Rauwolfia serpentina, Santalum album (Sandal wood tree), Cycas beddonei, Nepenthes Khasiana (Pitcher plant).

Zoological Survey of India reported that cheetah, pink headed duck and mountain quail have become extinct from India.

• ENDEMIC SPECIES OF INDIA

Species which are restricted only to a particular area are known as endemic. India has two hot spots of biodiversity and hence possesses a large number of endemic species. Out of 47,000 species of plants 7000 are endemic in India. Thus Indian subcontinents have 62% endemic flora, restricted mainly to Himalayas, Western Ghats and Khasi hills. Some of the important endemic flora include **orchids** (endemic to Eastern Himalayas, toothbrush orchid is endemic to Sikkim) and species like Nepenthes khasiana (pitcher plant), Platycerium (endemic to Manipur), Pedicularis perroter, Sapria himalayana, Uvaria lurida etc. (Fig 1).

Toothbrush orchid — *Nepenthes khasiana* (Pitcher plant) — *Platycerium*

Fig. 1. Some endemic and endangered plants.

A large number of animal species (out of 81000 species) is endemic. About 62% amphibians (frogs, toads etc.) and 50% lizards, crocodiles are endemic to Western Ghats. Various species of monitor lizards (Varanus), reticulated python, viviparous toad, Nectophhryne and Indian Salamander are some important endemic species of India.

• CONSERVATION OF BIODIVERSITY

Biodiversity is the most valuable gift of nature and it is an insurance for our food and ecological security. It represents the very essence of life on the earth and maximum efforts should be done :

(i) To preserve the biological diversity.

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

(iii) To ensure that any utilisation of species and ecosystem is sustainable.

Following steps will go a long way in conserving biodiversity.

1. Biodiversity Inventories.

Better inventories and assessments are needed of current conditions, abundances, distributions and management direction for genetic resources, species populations, biological communities and ecological systems. For this purpose, the following activities should be supported.

- Surveys to map out the distribution of earth's ecosystems.
- Rapid assessment programmes to provide a **Snap-Shot** of richness of species.
- Extensive inventory efforts should be focused on poorly known habitats, degraded and multiple-use habitats as well as on vertebrates and vascular plants that can be used as **benchmarks** for habitat quality.
- Intensive inventories, to determine all the species present, from microbes to vertebrates, should be prepared at selected sites.

These efforts will lead to significant improvements in inventory processes, methodologies and technologies such as illustrated below :

- *Enable the best use of existing information and new technologies such as remote sensing and geographic information system (GIS).*
- *Provide estimates of resources in specific geographical units and evaluate their reliability.*
- *Eliminate redundant data collection, develop common terminology and promote data sharing through corporate data bases.*
- *Provide a base-line for monitoring changes in the condition of the resource.*
- *Provide up-to-date data bases using modelling techniques, accounting procedures and re-inventories.*
- *Ensure optimum utilisation of information management systems to provide maximum flexibility for data integration and manipulation.*

2. Conserving Biodiversity in Protected Habitats.

The two basic approaches to the wildlife conservation are as follows :

(A) In situ Conservation (Within habitat in nature).

In situ conservation involves protection of a group of typical ecosystems through a network of protected areas like biosphere reserves, national parks, sanctuaries, sacred lakes and reserve forests.

(i) Biosphere Reserves. Biosphere reserves conserve some representative ecosystems containing unique biological communities. They also ensure conservation of landscapes, species and genetic resources. At present, India has **13 Biosphere reserves** *viz.* Nanda devi (UP), Nokrek (Meghalaya), Manas (Assam), Sunderbans (West Bengal), Gulf of Mannar (Tamil Nadu), Nilgiri (Karnataka, Kerala, Tamil Nadu), Great Nicobars and Similipal (Orissa), Dibru saikhowa, Dehan debang, Pachmarhi, Agasthyamalai and Khanghendzonga.

(ii) Protected areas (National parks and sanctuaries). Protected areas of land or sea are specially dedicated to the protection of biodiversity and associated cultural resources. The World Conservation Monitoring Centre (WCMC) has recognised **37000 protected areas** around the world. As of September 2002, India has 581 protected areas (89 National parks and 492 wildlife sanctuaries).

National Parks. A national park is an area which is strictly reserved for the welfare of wildlife and where activities such as forestry, grazing, cultivation, habitat manipulation and private rights are prohibited. Major national parks with important wildlife are listed in Table 5.

Table 5. Major National Parks of India.

National park	Location	Important wildlife
Kaziranga	Sibsagar, Assam	One horned rhinoceros
Corbett	Nainital, Uttaranchal	Tiger
Sunderbans	West Bengal	Tiger, dolphin
Gir national park	Junagarh, Gujarat	Indian lion
Bandipur	Mysore, Karnataka	Elephant
Tandoba	Maharashtra	Four horned deer
Desert park	Jaisalmer, Rajasthan	Chinkara
Hazaribagh	Jharkhand	Nilgai
Periyar	Kerala	Elephant, tiger

Wildlife Sanctuaries. Sanctuaries are protected areas where killing, hunting, shooting or capturing of wildlife are prohibited. However, private ownership rights and forestry operations are permitted to the extent that they do not affect wildlife adversely. Some sanctuaries with major wildlife are shown in Table 6.

Table 6. Important Sanctuaries of India.

Sanctuary	Location	Major wildlife
Annamalai	Coimbatore, Tamil Nadu	Spotted deer
Jaldapara	West Bengal	Rhinoceros, elephant
Nagarjuna sagar	Andhra Pradesh	Chital, Jackal
Manas wildlife	Kamrup, Assam	Golden langur
Chilka lake	Balagaon, Orissa	Cranes, duck
Sultanpur lake	Gurgaon, Haryana	Migratory birds
Nal sarovar	Gujarat	Water birds

For plants, there is one gene sanctuary for citrus (Lemon family) and one for pitcher plant (an insect eating plant) in North East India.

(B) Ex-situ Conservation (Outside habitats).

Ex-situ conservation is achieved by establishment of gene banks, germ plasm banks, seed banks, zoos, botanical gardens, genetic resource centres, pollen grains, tissue culture and DNA banks. Here endangered plants and animals are collected and bred under controlled conditions in captivity under human care.

The International Board for Plant Genetic Resources was framed in 1974 with its Head quarters in Rome. By 1985, a chain of 43 gene banks were set up in different countries. In India, we have following important gene bank/seed bank facilities.

(i) National Bureau of Plant Genetic Resources (NBPGR), New Delhi. Here agricultural and horticultural crops and their wild varieties are preserved by cryo-preservation of seeds, pollens etc. by using liquid nitrogen at a very low temperature of –196°C. Varieties of rice, tomato, onion, chilli, turnip, radish, carrot, tobacco, poppy etc., have been preserved for several years without losing seed viability.

(ii) National Bureau of Animal Genetic Resources (NBAGR), Karnal, Haryana. It preserves semen of domesticated bovine animals.

(iii) National Facility for Plant Tissue Culture Repository for the conservation of varieties of crop plants or trees by tissue culture. This facility has been created within the NBPGR. The G-15 countries have also resolved to set up a net work of gene banks to facilitate the conservation of varieties of aromatic and medicinal plants for which India is the networking coordinator country.

3. Restoration of Biodiversity.

Biodiversity is threatened not only by reduction of habitat area but also by degradation of quality of the remaining habitats. By restoring both the extent and quality of important habitats, restoration programmes provide refuges for species and genetic resources that might be lost otherwise. **Several techniques** are used in India to restore ecosystems depending on the nature of the ecosystem and the impact type being addressed. These techniques include vegetation, planting to control erosion, fertilization of existing vegetation to encourage growth, removal of

contaminated soils, fencing to prevent cattle, reintroduction of extirpated species, restoration of hydrologic connections to wetlands, etc.

Rapid reforestation to reinstate green plant cover on barren lands, hill slopes, highways, roads etc. taking care to ensure that the species planted are ecologically compatible to the region and useful to the local people, will go a long way in restoring biodiversity. However, restoration is not a substitute for the preservation or good management as it is both expensive and time consuming.

4. Imparting Environmental Education.

People at large should be motivated to conserve resources, to avoid extravagance and educated properly regarding ecological issues. All efforts should be made to conserve indigenous knowledge, traditions and environment friendly practices.

5. Population Control.

Effective population control measures have to be taken as a top-priority issue in the national agenda by involving people of all political parties, religious faiths and social organisations. Suitable incentives and disincentives should be in-built into the strategies specially formulated for this purpose.

6. Enacting, Strengthening and Enforcing Environmental Legislations.

Existing environmental laws against ecological unsound practices should be strengthened and enforced ruthlessly. Simultaneously, voluntary organisations should be motivated to include protection of biodiversity as a major and priority issue in their agenda.

7. Controlling Urbanization.

Ever-increasing urbanization and expansion of urban settlements should be controlled. Biological diversity should be infused into the urban localities.

8. Reviewing the Agricultural Practices.

We should refrain from temptation of high yields and making a fast buck at the cost of sustainable development. So try to infuse diversity in our agricultural practices by restoring to **mixed cropping polyculture** and tolerance to wild plants and other life forms around agricultural fields. A healthy soil should be maintained by using natural manures and less synthetic fertilizers and pesticides. All efforts should be made to maintain a balanced prey-predator relationship in agro-ecosystems.

• QUESTIONS

1. Briefly discuss major uses of forests. How would you justify that ecological uses of forests surpass commercial uses?
2. What are the main causes and consequences of deforestation?
3. Explain droughts and floods with respect to their occurrence and impacts.
4. Should we build big dams? Give arguments in favour of your answer.
5. Discuss major environmental impacts of mineral extraction.
6. How modern agriculture contributes to environmental degradation?
7. Give a brief account of renewable and non-renewable energy resources.
8. Enumerate applications of solar energy.
9. What is soil erosion? How can it be checked?
10. How can you conserve different natural resources.

11. Explain genetic, species and ecosystem diversity.
12. Discuss consumptive and productive use values of biodiversity.
13. Comment upon Indian biodiversity with special reference to a megadiversity nation.
14. Discuss salient features of hot spots of biodiversity.
15. What are the major causes of man-wildlife conflicts? Mention the remedial steps that can curb the conflict.
16. What is meant by in situ and ex situ conservation of biodiversity ?
17. Enumerate important biosphere reserves, national parks and wildlife sanctuaries. Also mention the state where they are located.

SHORT ANSWER QUESTIONS

1. *List some renewable and non-renewable resources of energy.*
   Ans. Renewable or non-conventional sources are : solar energy, wind energy, geothermal energy, ocean energy, tidal energy etc. Non-renewable or conventional sources are : thermal power, hydel power and nuclear power.
2. *What is ecocide?*
   Ans. The exploitation of the environment which involves senseless poisoning of the earth, air, water as well as destruction of forest wealth is called ecocide.
3. *Why afforestation is needed?*
   Ans. The development of forest on waste lands is known as afforestation. It is needed :
   (i) To check land degradation.
   (ii) To put waste lands to sustainable use.
   (iii) To increase the availability of biomass, fuel and fodder.
   (iv) To restore the ecological balance.
4. *List modern methods of forest management.*
   Ans. Modern methods include use of fertilizers, irrigation, bacterial and mycorrhizal inoculation, disease and pest management, control of weeds, breeding of elite trees and tissue culture techniques.
5. *State world's total quantum of water.*
   Ans. It is 1.4 billion cubic kilometre.
6. *How much water is available for consumption?*
   Ans. Out of the estimated 1.4 billion km^3 of total water present on earth, only 33400 m^3 of water is available for drinking, agriculture, domestic and industrial consumption.
7. *What are the effects of excessive use of ground water?*
   Ans. It results in land subsidence, lowering of water table and water logging.
8. *How the depleted water table can be raised?*
   Ans. By recharging with rain water harvesting which means collecting rain water on the roofs of buildings and storing it underground for latter use.
9. *State briefly hydrological cycle.*
   Ans. Hydrological cycle consists of a balanced continuous process of evaporation, transpiration, precipitation, surface run off and ground water movements. This natural cycle helps in exchange of water between air, land, sea, plants and animals.
10. *Name the minerals mined to the maximum extent.*
    Ans. Coal, petroleum, iron ore, aluminium and phosphate.
11. *What can farmers do to increase agricultural production without increasing land use?*
    Ans. Farmers can use pesticides such as insecticides, herbicides, fungicides, rodenticides, synthetic fertilizers, biocides and biofertilizers to enhance food productivity.

12. *Give two examples of aquatic animals which accumulate pesticides?*
Ans. Protozoa-**Blepherisma** concentrate DDT by about 3000 fold in 12 hours. The fish **Gambusia affinis** accumulates DDT to 25000 folds in a few hours.

13. *Who synthesized DDT first?*
Ans. DDT was first synthesized by **Othmarzeidler** of Germany in 1874 and rediscovered by Swiss entomologist **Paul Mueller** in 1939 who won **Noble Prize** for uncovering its powerful insecticidal properties.

14. *Does biodegradation of pesticides always yield harmless products?*
Ans. No, sometimes degraded intermediates may be more toxic than the original pesticides. For example, biodegraded product DDD is more toxic than DDT.

15. *Mention major constraints in the development of thermal power plants.*
Ans. Lack of adequate financial resources, acquisition of land, provision of other infra structural facilities, clearance from environmental angle, rehabilitation of displaced population are some of the main constraints in the development of pollution free power plants.

16. *Which country is the largest producer of wind power?*
Ans. California, with 1700 machines generating 1500 megawatts is the world's largest producer of wind generated power. This supplants the need for two nuclear power plants.

17. *How much is the gestation period of wind energy?*
Ans. Wind energy involves a low gestation period of five months.

18. *State government incentives for generating wind power.*
Ans. The government is providing various incentives such as 100% depreciation, free import duty for certain components for the manufacture of wind turbines, exemption from excise duty, sales tax etc.

19. *Mention drawbacks of wind energy.*
Ans. Location of wind farms on migratory routes could spell hazards to birds and disaster for avian population. Their appearance on the landscape and continuous whirling can be irritating.

20. *Where does the world's largest geothermal energy production facility exist?*
Ans. It exists near **San Fransico** in US at the location known as Geysors. The electrical output was 14.3 billion kW in 1988 which is equivalent to power produced by two large nuclear power plants.

21. *Name the countries where geothermal facilities also exist.*
Ans. Mexico, Italy, Philippines, Japan and Iceland generate a total power of 3000 MW.

22. *Who developed the solar trough concept for producing electricity?*
Ans. By Charles Abbott in 1930.

23. *What is the use of solar passive concept?*
Ans. Solar passive concept can be incorporated in building designs and solar huts.

24. *Name new approaches to produce electrical power from sunlight.*
Ans. Power tower and solar ponds are used.

25. *How power tower method is more economical than solar trough system?*
Ans. In power tower method, an array of sun tracking mirrors is used to focus the sunlight falling on a large area of land onto a boiler mounted on a tower. The intense heat produces steam in the boiler which drives a turbogenerator. This system generates more power than solar trough system.

26. *Which ingredients are used for generating power from solar ponds?*
Ans. Plenty sunshine, water and brine (NaCl or $MgCl_2$) are used.

27. *Who set up the first solar pond?*
Ans. India's first solar pond for harvesting solar energy was set up in 1970 by scientists of Central Salt and Marine Science Research Institute (CSMSRI)

Bhavnagar, Gujarat. Also a 6000 square metre solar pond being set up in Bhuj, Gujarat to provide hot water.

28. *What are the limitations of solar ponds?*
Ans. Harnessing solar energy from saline water ponds is highly site dependent. It depends on the cost of excavation and availability of salt. The performance of solar ponds depends on solar irradiation and ground thermal conductivity.

29. *List some applications of solar energy.*
Ans. Solar air and water heating, solar desalination, solar cooker, solar refrigeration, space conditioning, green house technology, solar stills, solar air crafts, generation of fuels etc.

30. *Why solar installations are failing?*
Ans. The main cause of solar installation failure is the selection of unsuitable materials which are not designed to tolerate varied fluctuations in different weather conditions.

Faulty engineering design, improper choice of pumps, seals and gaskets may lead to premature failure. So heat exchangers need to be selected carefully.

Control system sensors may be improperly positioned.

Lack of repair and maintenance services.

31. *What are the environmental implications of solar energy?*
Ans. (i) The use of solar energy is a completely benign operation. However, the sites for large installations of solar power plants should be selected without reducing the forest cover. (ii) CO_2 produced while forming silicon from silica may increase the atmospheric temperature causing green house effect. (iii) Silicon dust is also an important occupational hazard.

32. *Name some solar cells.*
Ans. Solar cells are CdS (*n*-type), Cu_2S (*p*-type), gallium arsenide and irridium phosphide.

33. *State the recent world's largest earthquake.*
Ans. On December 26, 2004 the world's fifth largest earthquake with a magnitude of 8.9 strucked the coast of the Northern Indonesia Islands of Sumatra, triggering tsunamis that crashed into Srilanka and India, drowning over one lakh people and swamping tourists in Thailand and Maldives.

34. *How much is the world reserve of petroleum?*
Ans. About 800 billion barrels which is likely to be exhausted in the next century.

35. *Who run the India's first pilot plant using leafy waste to produce electricity?*
Ans. The plant was run by Central Mechanical Engineering and Research Institute, Durgapur in 1988.

36. *How hydroelectricity generation can be made viable?*
Ans. By adopting a long term programme of afforestation, environmental conservation, housing, public health, transportation and ensuring close coordination among these departments.

37. *State current data (2010) of electricity generation from renewable sources of energy to reduce carbon emission.*
Ans. In India, electricity generation up to 2025 aims at : solar energy 7 mega watt (MW) to 20000 MW, wind energy from 11000 to 33000 MW, Hydroelectric power from 84000 to 120000 MW, Nuclear energy from 4000 to 63000 MW, Biomass energy from 916 to 18000 MW.

38. *What is soil erosion or gravity erosion?*
Ans. Soil or gravity erosion refers to all physical processes that loosen or tear off soil particles and displace soil texture from the parent sites.

39. *How soil erosion occurs? What are the steps involved in its mechanism?*
Ans. Soil erosion is due to instability of land vis-a-vis gravity and the balance is directly lost due to excessive moisture or water in the earth mass. Mechanism

involves **(i)** Loosening and detachment of soil particles from the soil mass and **(ii)** Removal and transport of detached soil particles by wind.

40. *Define mass wasting.*

Ans. Land slides, torrents or river erosion entail mass movement of fractured rock, other unconsolidated materials and of course soil which is known as mass wasting.

41. *What is the number of species existing on this biosphere?*

Ans. Current estimates indicate that about 10 to 80 million species exist on earth. However, only 1.5 million living and 300,000 fossil species have been assessed and enlisted so far.

42. *State biogeography.*

Ans. Biogeography comprising of phytogeography (floristic) and zoogeography (fauna) deals with the distribution, evolution, dispersal and environmental relationship of plants and animals. In India, Indian subregions include Himalayan slopes to cape comrin. The fauna is characterized by153 families of terrestrial vertebrates and 2.5 lakh species of plants.

43. *What information can be gained from IUCN Red Data Book or the Red List?*

Ans. The IUCN Red List is a catalogue of taxa that are facing the risk of extinction. The red data symbolizes the warning signal for those species which are critically endangered. It is the most comprehensive inventory of the global conservation status of plants and animal species. The Red List provides information to international agreements such as the Convention on Biological Diversity and the Convention on International Trade in Endangered Species.

44. *Give an account of endangered species.*

Ans. Currently, the IUCN Red List contains more than 18000 species out of which 11096 species (5611 plants and 5485 animals) are endangered. About 1939 species (1014 plants and 925 animals) are assessed as critically endangered.

45. *What is exotic species?*

Ans. Any species which is not a natural inhabitant of the local habitat but is introduced into the system accidently or deliberately like Lantana camara, is called exotic species.

46. *Explain briefly endemic species of India.*

Ans. The biodiversity rich zones of India, *i.e.*, Western Ghats and North-east Himalayas, are inhabited by a large number of endemic species. About 33% of the flowering plants are endemic to our country. Out of the recorded vertebrates, 62% amphibians, 53% fishes, 36% reptiles and 10% mammalian fauna are endemic.

47. *List reasons responsible for the depletion of wildlife.*

Ans. Deforestation for cultivation, construction of dams, power stations, highways, railways, mines, industrialisation and urbanisation etc. reduce area for the free movement of wild animals which retards reproductive capabilities of animals. Other reasons are :

- Habitat fragmentation.
- Hunting methods
- Environmental pollution
- Poaching
- Natural calamities
- Climatic changes.

48. *Name in situ conservation strategies for biodiversity.*

Ans. These strategies include biosphere reserves, protected areas, sacred forests and sacred lakes.

49. *What are the advantages and limitations of ex situ conservation of wildlife in captivity?*

Ans. **Advantages** of wildlife management in captivity are :

- The organisms are assured of food, water. shelter, security and hence have longer life span and breeding activity thereby increasing the number of offsprings.
- The chances of survival of endangered species increase.
- This offers the possibility of using genetic techniques to improve the species concerned.

Limitations of wildlife management in captivity are :

- Since maintenance and breeding of plants and animals under captivity is very expensive, it can be adopted only for a few selected species.
- Wildlife captivity only under a set of favourable environmental conditions deprives the organisms the opportunity to adopt to ever-changing natural environment. Therefore, new life forms can not evolve and thus the gene pool gets stagnant.

50. *Name some specific projects which have been launched in India for the protection of animals.*

Ans. Gir lion project, crocodile breeding project, snow leopard project, project tiger and project elephant.

51. *Give an account of conservation approaches in India.*

Ans. In India, there are 13 major biosphere reserves, 581 protected areas, 89 national parks, 492 wildlife sanctuaries, 1500 botanical gardens, 800 zoos, 3 (out of 43) gene banks and 2 (out of 25) hot spots of biodiversity in Western Ghats and Eastern Himalayas.

MULTIPLE CHOICE QUESTIONS

1. Natural resources are

(a) Renewable (b) Non-renewable

(c) Conventional or Non-conventional (d) All

2. Renewable resources are

(a) Solar energy (b) Wind energy

(c) Both (a) and (b) (d) Coal and oil

3. The forest area recommended by National Forest Policy (1988) is

(a) 33% for the plains (b) 67% for the hills

(c) Both (a) and (b) (d) 50% for the plains

4. The main cause for deforestation is

(a) Increasing human and livestock population

(b) Plantation of monoculture

(c) Rainfall (d) Floods and drought

5. The derelict land or mine spoil can be reclaimed to a semi-natural condition by

(a) Revegetation (b) Gradual restoration of flora

(c) Prevention of drainage discharge (d) All methods

6. Select the correct statement(s) about sun in the solar system

(a) Sun is a big nuclear fusion reactor

(b) Nuclear fusion reactions occur at the core of the sun

(c) Solar power operates on hydrogen fuel which will last for 10 billion years

(d) All statements are correct

7. Both power and manure are provided by

(a) Nuclear reactors (b) Thermal plants

(c) Biogas plants (d) Hydroelectric power

8. Tidal power plants are in operation in
   (a) Russia (b) France
   (c) Nova scotia (d) All of these
9. Sunlight may be converted into electricity through
   (a) Photovoltaic cell (b) Galvanic cell
   (d) Carbon electrodes (d) Platinum electrodes
10. Gasohol is a mixture of
   (a) Gasoline blended with 20% methanol or ethanol
   (b) Gasoline and petroleum ether
   (c) Methane and CO_2
   (d) Methane and SO_2

FILL IN THE BLANKS

1. ..... resources can not be generated.
2. Maximum number of dams in India are in the ..... state.
3. The largest dam in terms of capacity is ..... on river Satluj in H.P.
4. Environmental activist Medha Patekar has taken up issues related to ..... dam.
5. A layer of sediment or rock that is highly permeable and contains water is called ..... .
6. When annual rainfall is below normal ..... conditions are created.
7. The low grade ores can be better utilized by using ..... technique.
8. Over irrigation of croplands for good growth of crops often leads to ..... .
9. Ocean tides are produced by ..... forces of sun and moon.
10. ..... is considered as an alternative perfect future source of energy.

ANSWERS

Multiple Choice Questions.

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

Fill in the Blanks.

1. Non-renewable
2. Maharashtra
3. Bhakra dam
4. Sardar Sarovar
5. Aquifer
6. Drought
7. Microbial leaching
8. Water logging
9. Gravitational
10. Hydrogen

UNIT

5

ENVIRONMENTAL EDUCATION AND MANAGEMENT

STRUCTURE

• ENVIRONMENTAL EDUCATION

Objectives.

The education for environmental awareness is essential for the younger and older generations. Education in India is mainly a state subject and the responsibility is that of the **Ministries of Education** at the Centre and States. There is a **Chinese** proverb which says *if you plan for one year, plant rice, if you plan for 10 years, plant trees and if you plan for 100 years, educate people.*

Environmental education helps students and general public towards :

- **Awareness** *i.e.*, acquire sensitivity to the total environment and its allied problems.
- **Skill** *i.e.*, acquire skills for identifying environmental problems.
- **Knowledge.** To know conservation of natural resources.
- **Evaluation ability.** To evaluate environs measures and education programmes in terms of social, economic, ecological and aesthetic factors.
- **Attitude and participation.**

Principles of Environmental Education.

- *To consider environment in its totality (natural, artificial, technological, ecological, moral, aesthetic).*
- *To consider a continuous life process.*
- *To be interdisciplinary in approach.*
- *To focus on current, potential environmental situations.*
- *To emphasize active participation in prevention and control of pollution.*
- *To examine root cause of environmental degradation.*
- *To provide an opportunity for making decisions and accepting their consequences.*

Environmental Educational Programmes.

It involves a three-fold classification of environmental education based on different disciplines.

1. **Environmental Studies.** It is concerned with environmental disturbances and minimisation of their impacts through changes in social sciences.

2. **Environmental Science.** It deals with the study of the processes in water, air, soil and organisms which lead to environ damage.

3. **Environmental Engineering.** It involves the study of technical processes used to minimise pollution.

Environmental Education Among Students.

The environ scenario of India is very wide indeed. At the first level, special attention must be paid to children. They are to be made aware of health, nutrition, sanitation, hygiene, development, water and food contamination, fodder and fuel wood etc. NGO's have to play a significant role in environmental education and awareness.

A. Formal Environmental Education.

The spectrum of EE has four major interrelated components, *i.e.*, Awareness, real life situation, conservation and sustainable development.

1. **Primary School Stage.** The attempt is made to sensitize the child about environs. Emphasis should be mostly (75%) on building up awareness, followed by real life situation (20%) and conservation (5%). Teaching strategy includes audio-visual and field visits.

2. **Lower Secondary Stage.** At this level objective must be real life experience, awareness and problem identification. The contents are supplemented with general science. Teaching, practicals and field visits are to be done.

3. **Higher Secondary School Stage.** The emphasis must be on conservation, assimilation of knowledge, problem identification and action skills. Contents may be science-based and action oriented work.

4. **College Stage.** Maximum emphasis should be on knowledge regarding sustainable development based on experimence with conservation. The content must be college based on Science and Technology.

Teaching practicals and action-oriented field work is to be done. In the school education, NCERT has been playing vital role in designing syllabi, text books, guide books, charts and kits teaching materials and other aids.

5. **University Education.** EE at this level is being looked after the UGC. **The university education** has three major components— Teaching, Research and Extension. At post graduate level, **four major areas are recognised** *environmental engineering, conservation and management, environmental health, social ecology.*

B. Non-formal Environmental Education.

This education is designed for any age group, participating in cultural, social, economic development of the country. They form clubs and arrange exhibition, public lectures, meetings, environmental campaigns. Following are the main constituents of this education.

1. **Adult Education.** Adults may influence the society to protect the precious environs by generating posters, slides, audio-visual and information pictures.

2. Rural Youth and Non-student Youth. They may act as volunteers.

3. Tribals and Forest Dwellers. They are an important media to protect the forest wealth.

4. Children Activities. The National Museum of Natural History (NMNH) conducts spot painting, modelling and poster design about environment for children.

5. Eco-development Camps. Currently a set of a guide lines has been prepared by **D.O. En.**

- *To create awareness in youth about basic ecological principles.*
- *Enable exposure to real lie situations. Acquaint with the conservation needs, problems and efforts. Acquaint with the practice of sustainable development.*

6. Non-government Organisations. There are more than 200 NGOs, of which most are involved in EE and awareness, others in pollution control, nature protection and conservation, rural development, waste utilization, wild life conservation, floristic and funal studies, afforestation and social forestry and eco-development.

7. Public Representatives. India has environmental forums for MPs and MLAs to discuss environmental problems facing the country. They stimulate public interest for saving the environs.

8. Training Executives. Regular courses should be arranged for environ activities among administrators.

9. Research and Development Programmes. Such R and D efforts are supported by D.O. Environment in Biosphere and Man.

10. Foundation Courses. The courses for the probationers selected for the IAS, IFS, IPS and cadets of three wings of Armed Forces need to be supplemented with foundation courses on environment relevant to their area of specialisation.

11. Development of Educational Material and Teaching Aids. Materials for media (T.V., radio, films, news papers etc.), audio, mobile exhibitions, audio-visual materials must be operated by competent manpower. One such centre in India is Centre for Environmental Education, Ahmedabad.

12. Development of Trained Manpower. Department of Environment (DOE) must organise training programmes for the professors, technical personnel, lecturers and legal experts.

13. National Environment Awareness Campaign or National Environment Month. Commencing from 1986, DOEn conducts NEAC and NEM. From November 19th to December 18th every year is observed as NEM.

14. World Environmental Day. All Govts. in the states, UTs, universities, schools, colleges, academic institutions and voluntary organisations organise suitable activities on WED, *i.e.*, 5th June of each year. DOE supports the function financially.

C. Environmental Information.

DOE had set up a programme, *i.e.*, Environmental Information System (ENVIS) in 1982. It is a decentralised system using distributed network of data bases for collection of environmental information. ENVIS network with DOE consists of 10 ENVIS centres on diverse areas of environment. It is established in specialised and reputed institutions in the country.

• WOMEN EDUCATION

Today, the need of the hour is environmental education and awareness among women about the environmental protection. Women, particularly poor village women, are the worst victims of environmental degradation. Their days starts with a long march in search of basic items like fuel, fodder, vegetables and water. So there must be stringent legislation about women education.

- Women should be given better educational opportunities.
- Women should be educated about environmental deterioration and its protection.

United Nations recognised the need of women in decision making process, in planning of natural resource use, protection of green cover and in population stabilisation. Women have been the significant factor in environmental movements. By education, women can learn :

- How to handle environmental issues.
- How to lead a better life with less pollution.
- How to prevent the ecological crisis.
- How to ensure socio-economic development and make this earth a better place to live in for the present and future generations.

• INITIATIVES BY NON-GOVERNMENT ORGANISATIONS (NGO'S)

NGO's, the non-profit organisations, initiate environment awareness among people and act as catalyst for environmental protection. The **Ministry of Environment and Forests extends** support to NGO activities and conducts many of its own programmes through them. NGO's Act as eyes and ears of the government.

Initiatives taken by NGO's.

- Environmental education and awareness among people.
- Environmental (air, water, soil, noise) pollution control.
- Protection of forest wealth.
- Afforestation and social forestry.
- Floristic and formal education.
- Wild life conservation.
- Recycling and waste utilisation.
- Rural development and eco development.
- Population stabilisation and family planning.
- Development of non-polluting renewable energy sources.
- Emphasising the use of non-conventional, pollution free sources of energy (solar, wind, tidal, biogas, gobar gas, ocean energy etc.) instead of thermal, hydel and nuclear energy.
- Conservation of biological diversity.
- Healthy crop land and grass land.
- Encouraging the use of biofertilizers.
- Developing new dimensions to national security.
- Sustainable development.

• SOME IMPORTANT NGO'S AND THEIR INITIATIVES

- **Kalpavriksh (KV).** This organisation started in 1979 as a movement opposed to the destruction of Delhi's green areas. KV is mainly conducting research on environmental subjects, such as an impact assessment study

of the Narmada Valley Project, pesticide use in India, air pollution in Delhi and mining activities. KV is functioning as a resource group for NCERT and other agencies on environment education.

- **Kerala Sastra Sahitya Parishad.** KSSP is an important national institution with a membership of over 25,000 with around 900 units spread over the State of Kerala. The activities of the Parishad encompass eco development, creating an awareness on water and energy conservation, encouraging the use of non-conventional sources such as smokeless chulhas.
- **World Wide Fund for Nature, India (WWWF India).** WWF has approximately 200 volunteer associates and 10,000 subscriber supporters. The major activities of this organisation are conservation of the country's natural heritage to research, field project, education and training.
- **Bombay Natural History Society (BNHS).** BNHS has contributed significantly in saving the valuable tropical forests of Silent Valley in Kerala.

• OTHER NGO'S

- Indian Environmental Association, Delhi (1980).
- Indian Society for Naturalist **(INSONA)** Gujarat (1975).
- Society for Clean Environment **(SOCLEEN)** Maharashtra.
- Himalayan Research and Development Group **(HRDG)** Nainital (1982).
- People Association for Himalayan Area Research **(PAHAR),** Nainital (1982).
- Uttrakhand Research Institute, U.P. (1975).

Society for Himalayan Environmental Rehabilitation and People Action, **(SHERPA)** (1984).

• IMPORTANT NGO'S MOVEMENTS

1. Chipko Movement (Wilderness Ethic) U.P. 1973.

Chipko (to hug or stick to) movement was launched in 1973 by Chandi Prasad Bhatt and Sunder Lal Bahuguna against large scale felling of trees by timber contractors in the Uttrakhand hills (U.P.). The starting point was Chamoli district of Garhwal region in U.P. Hill women took part in the campaign. They embraced trees and compelled the timber contractors to leave.

This novel campaign of saving hill forests and greenery soon spread all along the hill region (Salkane forest in Sirsi district) and to Karnataka in 1983 where it was named **Appiko**.

Chipko movement crossed geographical boundaries and observed as Chipko Day at New York, USA on April 29, 1983. Children assembled and hugged a big tree in Union Square Park.

2. Silent Valley Movement.

Silent valley occupies an area of 8950 hectares at an altitude of 3000 feet in Palaghat district, Kerala. It is surrounded by Nilgiri, Attapadi and pristine forests. The pristine tropical rain forest in the Western Ghats is a precious reservoir of genetic diversity from where life-saving drugs and other valuable materials can be extracted in near future.

The Kerala State Government decided to construct a dam in the Silent Valley of Palaghat district, Kerala, for the generation of 120 mega watts of electricity in 1976 at the cost of Rs. 25 crores (revised in 1984 to Rs. 51 crores). The proposed dam would store 270 million cubic feet water in a reservoir spreading over 700 hectares.

The Kerala based NGO's, Kerala Sastra Sahitya Parisad (KSSP) launched the Silent Valley Movement to save it from dam construction. Soon the apex policy making bodies NCEPC, DOEn and IUCN (International Union for Conservation of Nature and Natural Resources) and Prime Minister (Indira Gandhi) declared the Silent Valley as the **Biosphere Reserve**. Thus NGO's succeeded in protecting an important biosphere reserve.

3. Narmada Dam.

Narmada is the largest west flowing river arising from the Amar Kantaka Plateau in Shahdol district of M.P. and travels 1300 km draining 9.88 million hectares between Vindhya and Satpura ranges. The M.P. Government undertook a gigantic plan-Narmada Basin Development Programme which involves construction of 31 large dams for Narmada, 450 medium and thousands minor projects at a cost of Rs. 25,000 crores.

The **benefits** were projected—several million hectares of land irrigated, water supply to thousands of industries and several thousand mega watts of power etc. But according to **NGO**, massive damming of Narmada river could be a **blue print** for disaster. NGO's led by the environmentalist, Megha Patekar organised sustained movement to stall the projects of Sardar Sarobar and Narmada Sagar dams and partly succeeded.

• BISHNOIS : DEFENDERS OF THE ENVIRONMENT

The Bishnois are a small community in Rajasthan, India, who practise a religion of environmental conservation. They believe that cutting a tree or killing an animal or bird is blasphemy. Their religion, an offshoot of Hinduism, was founded by Guru Maharaj Jambaji, who was born in 1450 CE in the Marwar area. When he was young he witnessed how, during a severe drought, people cut down trees to feed animals but when the drought continued, nothing was left to feed the animals, so they died. Jambaji thought that if trees are protected, animal life would be sustained, and his community would survive. He gave 29 injunctions and principal among them being a ban on the cutting of any green tree and killing of any animal or bird. About 300 years later, when the King of Jodhpur wanted to build a new palace, he sent his soldiers to the Bishnois area where trees were in abundance. Villagers protested, and when soldiers would not pay any attention to the protest, the Bishnois, led by a woman, hugged the trees to protect them with their bodies. As soldiers kept on killing villagers, more and more of the Bishnois came forward to honour the religious injunction of their Guru Maharaj Jambaji. The massacre continued until 363 persons were killed defending trees. When the king heard about this human sacrifice, he stopped the operation, and gave the Bishnois state protection for their belief.

Today, the Bishnois community continues to protect trees and animals with the same fervour. Their community is the best example of a true Hindu-based ritual defense of the environment in India, and their sacrifices became the inspiration for the Chipko movement of 1973.

• THE ROLE OF GOVERNMENT IN ENVIRONMENTAL PROTECTION

The government is not just the protector of country's environment but it also has the role of destroyer if it neglects its responsibility. The government has immense responsibility for sustaining environmental consciousness. There is an ongoing debate with many environmentalists about the appropriate role of government for solving environmental problems. A few roles are illustrated below.

Regarding Global Hot Issues.

1. Issues such as global warming, ozone hole, ecological imbalance, deforestation, loss of biodiversity require much more government intervention. These issues demand high level of international cooperation.

2. Policies such as absolute limits on CO_2, **government funding** of alternative energy systems and coordinated efforts to purchase and protect **biodiversity hot spots** around the world need to be a **major components of future government policy.**

Facing Natural Disasters.

1. Facing increased probabilities of **natural** disasters (due to global warming), the government should move the people towards a more rational method of risk management in areas prone to natural disasters.

2. It is highly inefficient for the government to provide reconstruction aid to people living around areas that are both dangerous and prone to catastrophe. The government has two options.

(i) All people living in hurricane zones, flood plains or near fault lines should purchase private insurance or

(ii) Make it absolutely clear that people will not be compensated for their loss of property by the government if disaster strikes.

Such a policy will lead to dramatic shifts in the population densities in disaster prone areas of the country.

3. The **net effect** would be to dramatically reduce future losses of life and property. Thus the government could save **hundreds of billions** in future costs.

4. This policy would also force private actors (notably insurance companies) to fully take into account the effects of environmental externalities that have largely been ignored.

Regarding Personal Health and Risks.

Here the government must play an active role than typically advocated by some of the strongest proponents of free markets.

1. **Health and risk** is a highly complex and inter-connected system where we all are exposed to thousands of chemicals in a year. Many of these chemicals interact in ways that are not yet fully understood. Also it is hard to trace the origin of causative products.

The government can play a vital role to regulate the economy. People can also invest in making wise choices for themselves. For example, they should avoid fast foods or cold drinks.

2. The **Food and Drug Administration**, the Environmental Protection Agency (EPA) and the U.S. Department of Agriculture should all be **well-funded.**

3. These agencies should be decoupled from conflicts of interest with industry and their mandate to protect the public welfare through rational risk assessment should be strengthened.

Government's Role According to Proponents of Classic Liberalism.

1. Environmental arena can be improved by property rights, free markets, individual freedom and better scientific knowledge.

2. Private markets can lead to the increased preservation of environmental resources.

3. Externalities, *e.g.*, pollution should be internationalised.

Role of Government in National Policy.

The government should frame policies to :

1. Reduce population growth rate by 30% over the next five years.
2. Reduce livestock population by 30% over the next five years in order to cut down methane (green house gas) emissions.
3. Impose heavy penalties for motor vehicles exceeding emission levels.
4. Introduce CFCs substitutes to reduce ozone hole.
5. Shift to renewable alternatives.

• LEGAL ASPECTS

Important legal aspects in Government's environmental policy for ensuring environmental protection are listed below :

1. **Conservation of natural resources by** direct action such as declaration of reserved forests, wetlands and mangroves.
2. Protection of grazing land.
3. Scientific land use and enforcing strict reclamation regimes.
4. Checking further degradation of land and water through wasteland management and restoration of river water quality programmes.
5. Biosphere reserves for conservation of different ecosystems.
6. Designating areas valuable for serving as **hot spot screening nurseries** and gene sanctuaries.
7. Protection of endangered species.
8. Control of toxic and hazardous substances.
9. Prevention of denudation of forests.
10. Monitoring development through Environmental Impact Assessment studies of major project proposals.
11. Penal measures for industries which violate Pollution Control Act.

The Ministry of Environment and Forests have aimed at creating a comprehensive **legal and institutional infra structure** for safe guarding the environment. This includes framing of rules, notification of standards, recognition of environmental laboratories, delegation of powers, identification of agenda for management of **hazardous** chemicals etc. The existing acts, laws, rules etc. are also amended to make them more effetive.

Legislative Measures

India embarked a series of legislative measures and more than 200 Central and State Acts/Laws for the protection of environment. These are :

- The Water (Prevention and Control of Pollution) Act, 1974, amended in 1988.
- The Water (Prevention and Control of Pollution) Cess Act, 1977, amended in 1991.
- The Air (Prevention and Control of Pollution) Act, 1981, amended in 1988.
- The Environment (Protection) Act, 1986.
- The Forest Conservation Act, 1980, amended in 1988.
- The Wild Life (Protection) Act, 1972, amended in 1983, 1986, 1991 and 2002.
- The Motor Vehicle Act, 1988.
- The Biological Diversity Act, 2002.

Notifications.

- Environmental Impact Assessment Notification, 1994.
- **Eco Mark** Notification, 1994.
- Environmental **Audit** Notification, 1997.

Important Rules Framed by the Central Government.

- Hazardous Waste (Management and Handling) Rules, 1989, 2002.
- Biomedical Waste (Management and Handling) Rules, 1998, 2002.
- Municipal Solid Waste (Management and Handling) Rules, 2000.
- Plastic Waste Rules, 1999.
- Hazardous Micro-organisms and Genetically Modified Organisms Rules, 1999.
- The National Environmental Tribunals Act, 1995 and **National Environmental Appelate Act,** 1997 have been enacted with the objective of strengthening the provisions of environmental laws and **protection against environmental** aberration.

The Environment (Protection) Act, 1986

EPA was introduced in the wake of Bhopal disaster, 1984, EPA is the most comprehensive Act, incorporating all possible aspects related to environment protection. In fact, it is an **unbrella legislation** which provides a frame work for the coordination of Central and State governments and authorities established under Water and Air Acts.

EPA empowered the Central government to issue orders for closing down industries for non-compliance, imposing on them heavy penalty etc. Under the provision of EPA, every state has to set up **Green Beach** courts to attend to Public Interest Litigation (PIL) cases concerning environmental hazards affecting the quality of life of citizens.

• MULTIPLE CHOICE QUESTIONS

1. *Environment means*
   (a) Sum total of all conditions that affect life of living organisms
   (b) A beautiful landscape
   (c) Industrial production
   (d) Forest cover
2. *Components required to build up the environmental awareness include*
   (a) Exposure to real life situations (b) Sustainable development
   (c) Conservation of resources (d) All
3. *World environmental day is*
   (a) 14 November of each year (b) 5th June of each year
   (c) 25th December of each year (d) None
4. *Renewable resources of energy include*
   (a) Solar energy (b) Natural gas
   (c) Coal gas (d) Oil gas
5. *The hot beds of extincting forests are*
   (a) Madagascar (b) Western Ecuador
   (c) Eastern Himalayas (d) All
6. *Chipko Movement heralded by S.L. Bahuguna is also called*
   (a) Appiko Movement (b) SOCLEEN
   (c) Wilderness ethic (d) Kalpa vriksh

7. *The first Appiko was sparked off on*
   (a) September 8, 1983 (b) September 8, 1984
   (c) December 25, 1983 (d) June 5, 1990
8. *The quality of environment has deteriorated due to*
   (a) Public awareness (b) Non-government organisations
   (c) Air, water and soil pollution (d) None
9. *Important segments of environment are*
   (a) Atmosphere, biosphere (b) Lithosphere
   (c) Hydrosphere (d) All
10. *Water quality parameters are set for*
   (a) Drinking water (b) Industrial water
   (c) Agricultural water (d) All
11. *Tidal power plants are in operation in*
   (a) Russia (b) France
   (c) Nova Scotia (d) All
12. *In India, the average intensity of solar radiation is*
   (a) $3 \cdot 45 \times 10^{23}$ kwh per year (b) 2·1 to 2·5 kJ per cm^2 per day
   (c) $2 \cdot 68 \times 10^{24}$ J per year (d) $3 \cdot 65 \times 10^{20}$ kwh per year
13. *About 10 m^3 of biogas has energy equivalent to*
   (a) 6·0 m^3 of natural gas (b) 3·6 L of butane
   (c) 7 L of gasoline (d) All
14. *DDT accumulation is about 25000 folds in*
   (a) Blepherisma (b) Gambusia affinis
   (c) Trout fish (d) Rohu fish
15. *Maximum tolerance limit of fluoride in drinking water is*
   (a) 1·0 ppm (b) 1·8 ppm
   (c) 1·5 ppm (d) 2·0 ppm
16. *The world's largest producer of wind generated power is*
   (a) California (b) Japan
   (c) CIS (d) India
17. *The world's largest geothermal energy production facility exists near*
   (a) Bhavnagar (b) San Fransico in U.S.
   (c) CIS (d) China
18. *The solar power concept for producing electricity was developed by*
   (a) Charles Abbott in 1930 (b) Charles Robert in 1925
   (c) L.D. Meyer (d) W.H. Wischmeier
19. *The ingredients used for generating power from solar ponds are*
   (a) Plenty sunshine (b) Water and brine
   (c) Both (a) and (b) (d) Water and $MgSO_4$
20. *Solar cells are*
   (a) CdS (*n*-type) (b) Cu_2S (*p*-type)
   (c) Irridium-phosphide (d) All

21. *The term ecosystem was proposed by*
(a) W.E. Odum (b) A.C. Tansley
(c) H.T. Odum (d) E.P. Odum

22. *The various ecosystems differ in respect of their*
(a) Gross structure
(b) Functions
(c) Species composition and rates in production
(d) All

23. *An industrial ecosystem is established in*
(a) Kalundborg, Denmark (b) Kirkend in Bihar
(c) Boston (d) CIS

24. *The first atom bomb was exploded over Hiroshima on*
(a) August 9, 1945 (b) August 6, 1945
(c) August 14, 1945 (d) August 9, 1946

25. *The world's worst nuclear accident occurred at Chernobyl on*
(a) April 25, 1986 (b) April 15, 1986
(c) August 9, 1986 (d) August 6, 1987

26. *The term green house effect was coined by*
(a) Robert Angus Smith in 1872 (b) J. Fourier in 1827
(c) U.S. Pilots (d) None

27. *The symptoms of polluted water are*
(a) No external matter on the surface
(b) Foul smell, bad taste, oil and grease on the surface
(c) No change in physical appearance
(d) Less density

28. *Sinks of atmospheric gases are*
(a) Ocean surface (b) Soil
(c) Vegetation (d) All

29. *The killer in Bhopal disaster was*
(a) Carbaryl (b) Methyl isocyanate
(c) Aldrin (d) Accidental fire

30. *Oceans are the source of*
(a) $(CH_3)_2S$ (b) CH_3SH and COS
(c) $CH_3—S—S—CH_3$ (d) All

31. *Turbidity in water may be checked by coagulant such as*
(a) Ferric chloride (b) Ferric sulphate
(c) Ferric alum (d) All

32. *Which among the following are more resistant to undergo decomposition in soil?*
(a) Carbohydrates (b) Tannins and lignins
(c) Proteins (d) Lipids

33. *Asphyxiation is caused by*
(a) HCN, $COCl_2$ (b) NO_x
(c) $CHCl_3$ (d) AsH_3

34. *The most toxic species in water is*
(a) Hg^{2+} (b) Hg_2^{2+}
(c) CH_3Hg^+ (d) None

35. *Life saving gas in the atmosphere is*
(a) Ozone in the stratosphere (b) Water vapour in the troposphere
(c) Oxygen charged in the mesophere (d) Nitric oxide in the ionosphere

36. *Sulphurous smog is also known as*
(a) Photochemical smog (b) London smog
(c) Los Angeles smog (d) Urban smog

37. *We get our supply and reserves of fresh water from*
(a) Hydrological cycle (b) Carbon cycle
(c) Nitrogen cycle (d) Snow fall

38. *The global warming potential is highest in*
(a) CFC-11 (b) CFC-12
(c) HCFC-22 (d) N_2O

39. *Warm rain is caused by*
(a) NaCl or AgI (b) $NaNO_3$ or $AgNO_3$
(c) $MgCl_2$ or AgCl (d) NaCl or KI

40. *A series of chloro fluoro carbons were developed by*
(a) Du Pont in 1940 (b) Charles Abbott
(c) Tansley (d) Wien

41. *Pollutants emitted by jet planes are*
(a) Smoke (b) Aerosol
(c) Smog (d) Fog

42. *Treatment for drinking water supply requires*
(a) Sedimentation (b) Electrodialysis
(c) Disinfection by chlorination (d) Filtration through sand bed

43. *Maximum permissible noise level for residential areas near road traffic is*
(a) 70 dB (b) 85 dB
(c) 100 dB (d) 120 dB

44. The world's fifth most devastated undersea earthquake (Tsunami) that strucked Indonesia, Sri Lanka and India was occurred on
(a) December 26, 2004 (b) January 26, 2005
(c) December 15, 2004 (d) January 15, 2005

45. *Equipments used for noise measurement is/are*
(a) Cassette recorder (b) Pen recorder
(c) Sound level meter (d) All

46. Elisa test is used to detect
(a) Cholera (b) Malaria
(c) AIDS (d) TB

47. *Solid waste management is best conducted by*
(a) Incineration (b) Sanitary land fill
(c) Dumping into sea (d) Vacuum press filters

48. *Select the true statement about 25 hot spots*
    (a) 15 Hot spots occur in tropical forests
    (b) 5 Hot spots occur in Mediterranean type and five are islands
    (c) Hot spots occupy about 20% of human population
    (d) All are correct
49. *The minerals mined to the maximum extent are*
    (a) Coal, petroleum and iron ore
    (b) Al and phosphate rock
    (c) Both (a) and (b)
    (d) Copper and gold
50. *The countries with population more than one billion are*
    (a) India, China
    (b) USA, Canada
    (c) France, Germany
    (d) South America, CIS
51. *Most populated city in the world is*
    (a) Mexico
    (b) Tokyo
    (c) Seuol
    (d) Mumbai
52. *The P-triangle is composed of*
    (a) Population, poverty and pollution
    (b) Poverty, flood, drought
    (c) Cyclones, typhoons
    (d) Biodiversity.
53. *Human Development Index (HDI) is based on the parameters*
    (a) Literacy, life span and standard of living
    (b) Growth of population and industry
    (c) Income of people
    (d) Education of an adult
54. *Automobile exhausts consist of*
    (a) SO_2, C, Pb
    (b) CO, NO_x, hydrocarbons
    (c) Both (a) and (b)
    (d) O_3, CO_2
55. *Acid rain consists of*
    (a) H_3PO_4
    (b) CH_3COOH
    (c) HNO_3, HCl, H_2SO_4
    (d) H_3PO_5
56. *The first outbreak of dengue in India occurred at*
    (a) Mumbai
    (b) Kolkata
    (c) Delhi
    (d) Kanpur
57. *Environment Impact Assessment (EIA) is a*
    (a) Self corrective tool
    (b) Impact assessment tool
    (c) Mitigative measure
    (d) All of the above
58. *The EIA clearance certificate for development projects is issued by*
    (a) The Supreme Court
    (b) High Courts of States
    (c) Ministry of Environment and Forests, Government of India
    (d) Union Territories
59. *Sustainable ecosystem consists of*
    (a) Land, forest and water ecosystem which can be renewed
    (b) Tropical forests
    (c) Coastal lakes
    (d) Agricultural ecosystem

60. *Microbial degradation of waste occurs in*
(a) Incineration (b) Composting
(c) Vitrification (d) Burning

61. *Sanitary land filling is suitable for*
(a) Biodegradable waste (b) Radio waste
(c) Non-biodegradable waste (d) Biomedical waste

62. *Select the correct statement about sun in the solar system*
(a) Sun is a big nuclear fusion reactor
(b) Nuclear fusion reactions occur at the core of sun
(c) Solar power operates on hydrogen fuel which will last for 10 billion years
(d) All statements are correct

63. *Environmental protection can be achieved through*
(a) A well orchestrated plan of action
(b) Educating the people
(c) Developing ecofriendly technologies
(d) All

64. *Imbalanced ecosystem will result in*
(a) Shortage of materials (b) Slackening of economic growth
(c) Struggle for existence (d) All

65. *The world's strictest provision for the control of air and water pollution is in*
(a) Japan (b) China
(c) India (d) USA

66. *The oldest environmental protection act in India was*
(a) Air (Pollution and Control) Act (b) The Bengal Smoke Nuisance Act
(c) The Factories Act (d) The Water Act

67. *The Central and State Pollution Control Boards were set up for enforcement of*
(a) The Biological Diversity Act, 2002 (b) The Forest Conservation Act, 1980
(c) The Environmental (Protection) Act, 1986
(d) The Motor Vehicle Act, 1988

68. *In India, Green Benches have been constituted in*
(a) West Bengal (b) Tamil Nadu
(c) Both (a) and (b) (d) Mumbai

69. *The Environment (Protection) Act, 1986 applies to pollution generated by*
(a) Public (b) Government agencies
(c) Both (a) and (b) (d) None

70. *Nuclear power is produced from*
(a) Nuclear fission (b) Petroleum combustion
(c) Wood combustion (d) Coal combustion

71. *Biosphere reserves have been declared for the conservation of*
(a) Water bodies (b) Different ecosystems
(c) Air (d) Soil

72. *Tree hugging movement is*
(a) Chipko Andolan (b) Green movement
(c) Silent Valley movement (d) Narmada dam movement

73. *The first UN conference on Environment was held in*
(a) Montreal (b) Stockholm
(c) Johannesburg (d) Rio Brazil

74. *The Historic Earth Summit held at Rio, Brazil in June 1992 is known as*
(a) UNIDO (b) UNESCO
(c) UNCED (d) UNFCCC

75. *Major products of energy plantation are*
(a) Wood, paper (b) Rayon, cellophane
(c) Plastic, plywood (d) All

76. *Biological control refers to*
(a) Control of organisms by themselves
(b) Control of an organism by using pesticides
(c) Control of an organism by another organism
(d) Control of organisms by using biocides

77. *Agenda-21 refers to*
(a) 1972 Stockholm Summit (b) 1992 Rio Summit
(c) 2002 Johannesburg Summit (d) 2000 Geneva Summit

78. *Industrial Revolution raised global CO_2 concentration to*
(a) 380 ppm (b) 450 ppm
(c) 750 ppm (d) 280 ppm

79. *Mine reclamation activities are undertaken by*
(a) Planting of trees (b) Seeding with grasses
(c) Contouring of spoil piles (d) All

80. *Nitrogen transformations by bacteria involve*
(a) Nitrogen fixation (b) Nitrification
(c) Nitrate reduction and denitrification (d) All

81. *In Antarctica, a huge chunk of ice shelf, of the size of Luxemburg, broke and sheered away into ocean on*
(a) March 2002 (b) May 2005
(c) June 2003 (d) April 2004

82. *CO_2 balance sheet per year includes*
(a) Emission by fossil fuels 20 billion tonnes
(b) Emission by deforestation and changes in land use 5-5 billion tonnes
(c) Uptake by ocean 5-5 billion tonnes
(d) All

83. *For the control of malaria, the Nobel Prize was awarded to*
(a) Paul Muller (b) Ross
(c) Stevens (d) Edward

84. *Study of habitat is known as*
(a) Ethology (b) Ecology
(c) Entomology (d) Epidemiology

85. *Seismograph is used for the measurement of*
(a) Earthquake (b) Humidity
(c) Light (d) Noise

86. *The unit of dose of ionising radiation is*
(a) ROM (b) RAD (c) CAD (d) ROD

87. *On earth the autotrophic components can directly fix*
(a) Chemical energy (b) Mechanical energy
(c) Light energy (d) All

88. *The backbone of biological chemistry is*
(a) C (b) N
(c) S (d) P

89. *Recycling of the earth's crust is called*
(a) Rock cycle (b) Geologic cycle
(c) Both (a) and (b) (d) Mineral cycle

90. *The major autotrophic metabolism occurs in*
(a) Green belt (b) Brown belt
(c) Soil (d) Water

91. *The dynamic balance exists among*
(a) Producer (b) Decomposer
(c) Consumer (d) All

92. *The developed countries accounts for over consumption of resources while the developing countries for*
(a) Population crash (b) Poverty
(c) Pollution (d) All

93. *Aggregation of organisms of different populations refers to*
(a) Diversity (b) Density
(c) Population (d) Community

94. *CFS is*
(a) Centre for fuel control (b) Chloro fluoro carbons
(c) Carcinogenic fluoride compound (d) All

95. *Acidity in rain is measured by*
(a) pH meter (b) Barometer
(c) Hygrometer (d) Ammeter

96. *Stone leprosy in buildings is caused by*
(a) UV rays (b) Acid rain
(c) Ozone depletion (d) Green house effect

97. Kyoto Protocol, which sets targets for emission reductions entered into force in
(a) February 2005 (b) May 1997
(c) March 1999 (d) June 2002

98. *Profuse growth of aquatic vegetation that reduces the dissolved oxygen content is called*
(a) Eutrophication (b) Algal bloom
(c) Both (a) and (b) (d) Fermentation

99. *Chemical substances indicative of water pollution are*
(a) Dissolved oxygen in water
(b) Biological Oxygen Demand (BOD) in waste water

(c) Chemical Oxygen Demand (COD) in water

(d) All

100. *Material cycles, that is, exchange of materials between living and non living components, include*

(a) Sedimentary cycles (b) Gaseous cycles

(c) Nutrient cycles (d) All

ANSWERS

1.	(a)	2.	(d)	3.	(b)	4.	(a)	5.	(d)	6.	(c)	7.	(a)	8.	(c)	9.	(d)	10.	(d)
11.	(d)	12.	(b)	13.	(d)	14.	(b)	15.	(c)	16.	(a)	17.	(b)	18.	(a)	19.	(c)	20.	(d)
21.	(b)	22.	(c)	23.	(a)	24.	(b)	25.	(a)	26.	(b)	27.	(b)	28.	(d)	29.	(b)	30.	(d)
31.	(d)	32.	(b)	33.	(a)	34.	(c)	35.	(a)	36.	(b)	37.	(a)	38.	(b)	39.	(a)	40.	(a)
41.	(b)	42.	(c)	43.	(a)	44.	(a)	45.	(d)	46.	(c)	47.	(a)	48.	(d)	49.	(c)	50.	(a)
51.	(b)	52.	(a)	53.	(a)	54.	(c)	55.	(c)	56.	(b)	57.	(b)	58.	(c)	59.	(a)	60.	(b)
61.	(a)	62.	(d)	63.	(d)	64.	(d)	65.	(a)	66.	(b)	67.	(c)	68.	(c)	69.	(c)	70.	(a)
71.	(b)	72.	(a)	73.	(b)	74.	(c)	75.	(d)	76.	(a)	77.	(b)	78.	(a)	79.	(d)	80.	(d)
81.	(a)	82.	(d)	83.	(a)	84.	(b)	85.	(a)	86.	(b)	87.	(c)	88.	(a)	89.	(c)	90.	(a)
91.	(d)	92.	(d)	93.	(a)	94.	(b)	95.	(a)	96.	(b)	97.	(a)	98.	(c)	99.	(d)	100.	(d)