NEW AGE

ENVIRONMENT AND ECOLOGY

Anil Kumar De • Arnab Kumar De

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Preface

The Hon'ble Supreme Court of India passed an order in 1991 for the introduction of a common course on Environment in colleges and universities at undergraduate levels for all disciplines. But the order was not properly implemented. Displeased with non-compliance of this order, the Supreme Court again ordered in 2003 for the introduction of Environment as a compulsory subject at higher secondary level in schools and undergraduate levels in colleges, and even issued warning of legal action, if necessary.

The introduction of the common course on environment and ecology under compulsion obviously brought confusion in the academic communities due to the lack of suitable textbooks in the subject and lack of orientation about the subject among the teachers and students of various disciplines. The authors, with their long experience in environmental teaching and research, took up the challenge and brought out a standard textbook.

The book is written as per UPTU syllabus and the various units associated with it have been presented in a simple and lucid style to suit the requirements of the course.

Glossary of key terms is given at the end for easy understanding of the subject while feedback exercises are intended to reinforce the knowledge of the students.

The book will be useful for the undergraduate students of arts, science, commerce, engineering, medicine, pharmacy, management and law who have environment related subject in their course.

The authors also welcome constructive suggestions and comments from fellow teachers and beloved students.

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Unit-I

A. ENVIRONMENT

1.1 DEFINITION

What is Environment and why do we now notice so much interest in Environmental Studies in recent years?

Environment is the sum total of all conditions and influences that affect the development and life of all organisms on earth. The living organisms vary from the lowest micro-organisms such as bacteria, virus, fungus, etc. to the highest, including man. Each organism has its own environment (physical and biological).

The word "environment" originates from "environ" which means things that surround. As per definition of the Environment Protection Act, environment includes all the physical and biological surroundings and their interactions.

The study of environment or rather environmental studies is a multi-disciplinary subject which needs knowledge interest from physical sciences (physics, chemistry, mathematics), biological sciences (botany, zoology, microbiology, biochemistry), social sciences, economics, sociology, education, geography) etc. Obviously, environmental studies has a broad base, which requires integrated approach for dealing with the various aspects.

1.2 ECOLOGY

The word "Ecology" was coined by a German biologist in 1869 and is derived from the Greek word, "Oikos" meaning "House". Ecology is the branch of science that deals with the study of interactions between living organisms and their physical environment. Both are closely inter-related and they have continuous interaction so that any change in the environment has an effect on the living organisms and vice-versa. Any unit of biosystem that includes all the organisms which function together (biotic community) in a given area where they interact with the physical environment is known as ecosystem.

The ecosystem is the functional unit in ecology as it consists of both the biotic community (living organisms) and the abiotic environment. The latter has close interaction essential for maintenance of life processes. The interaction is conducted by energy flow (solar energy) in the system and cycling of materials (natural cycles).

From the biological point of view, the ecosystem has the following constituents:

(i) Inorganic substances (carbon, nitrogen, carbon dioxide, water, etc.) involved in natural cycles.

(ii) Organic compounds (proteins, carbohydrates, humic substances) etc.

(iii) Air, water and substrate environment including the climatic regime and other physical factors.

(iv) Producers, autotrophic (i.e., self-sustaining organisms) green plants that can manufacture food from simple inorganic substances.

(v) Heterotrophic (i.e., that depend on others for nourishment) organisms, mainly bacteria, fungi and animals which live on other organisms or particulate organic matter.

(vi) Micro-consumers, decomposers, mainly bacteria, fungi which obtain their energy by breaking down dead tissues or by absorbing dissolved organic matter, extracted from plants or other organisms. The decomposers release

inorganic nutrients that are utilised by producers. They also supply food for macro-consumers or heterotrophic organisms. Bacteria, fungi (and animals) often excrete hormone-like substances that inhibit or stimulate other biotic components of the ecosystem.

Typical profiles of a grassland ecosystem and of a pond ecosystem are shown in Fig. 1.1.

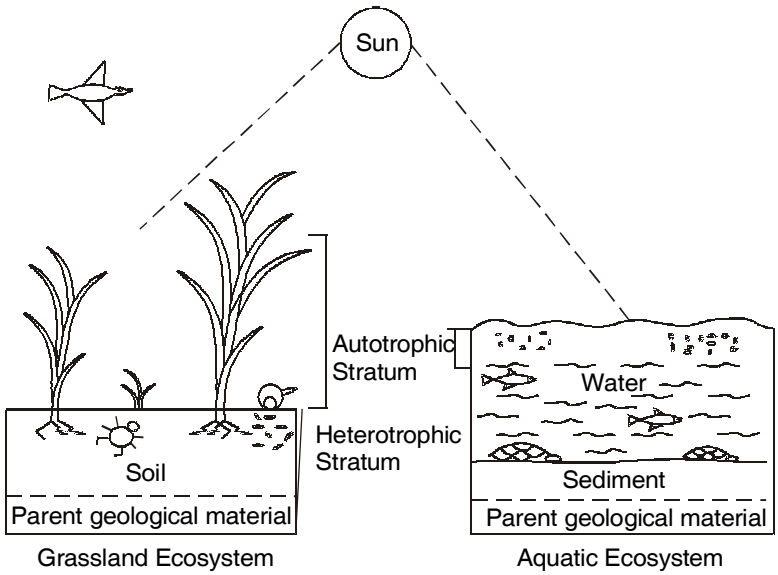

Fig. 1.1: *Grassland and pond ecosystems*

The common features of all ecosystems—terrestrial, freshwater, marine and agricultural—are the interactions between the autotrophic and the heterotrophic components. 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 soils and sediments.

1.2.1 Biomes

The Biome is a very large land community unit where the plant species are more or less uniform. It provides a basis for

natural ecological classification. The main biomes of the world are the Tundra; Temperate, Coniferous and Deciduous forests, Temperate grassland; Tropical Savanna; Desert and Tropical Rain Forests.

The *Tundra Biome* is in the polar region (north of latitude 60° North)—it is characterised by absence of trees, dwarf plants and an upper ground surface which is wet, spongy and rough.

Temperate Coniferous Forest Biome Coniferous forests occur in cold regions with high rainfall, long winters and short summers.

Temperate Deciduous Forest Biome These are high altitude regions about 3000–4000 metres above sea level as in the Himalayas. Here pines, fir and juniper trees are found.

Temperate Grassland Biome This type of grassland occurs where there is about 25 to 75 cm of rainfall per year. Such grasslands are found as tall grass prairies, short grass prairies of North America and also in South America, steppes of Southern Russia and Asia.

Tropical Savanna Biome These are tropical grasslands with scattered drought-resistant trees. These are found in eastern Africa, Australia and South America.

Desert Biome These are found in very dry environment where temperature changes from very hot to very cold.

Tropical Rainforest Biome These occur near the equator and offer the most diverse communities on earth with fairly high temperature and humidity. The annual rainfall is more than 200–225 cm. Here one finds dense vegetation consisting of tall trees covered with creepers and orchids, numerous herbs and shrubs. Tropical rainforest is the habitat of numerous vertebrate and invertebrate animals.

1.3 SCOPE

Environmental studies as a subject has a wide scope. It encompasses a large number of areas and aspects, which may be summarized as follows.

Natural resources — their conservation and management

Ecology and biodiversity

- Environmental pollution and control
- Social issues in relation to development and environment
- Human population and environment

These are the basic aspects of environmental studies which have a direct relevance to every section of the society. Environmental studies can also be highly specialized concentrating on more technical aspects like environmental science, environmental engineering or environmental management.

In the recent years, the scope of environmental studies has expanded dramatically the world over. Several career options have emerged in this field that are broadly categorized as:

(i) *Research & Development (R & D) in environment:* Skilled environmental scientists have an important role to play in examining various environmental problems in a scientific manner and carry out R& D activities for developing cleaner technologies and promoting sustainable development.

There is a need for trained manpower at every level to deal with environmental issues. Environmental management and environmental engineering are emerging as new career opportunities for environmental protection and management. With the pollution control laws becoming more stringent, industries are finding it difficult to dispose off the wastes produced. In order to avoid expensive litigation, companies are now trying to adopt green technologies, which would reduce pollution.

Investing in pollution control technologies will reduce pollution as well as cut on costs for effluent

treatment. Market for pollution control technology is increasing the world over. Cleaning up of the wastes produced is another potential market. It is estimated to be more than $100 billion per year for all American business. Germany and Japan having more stringent laws for many years have gained more experience in reducing effluents. Still there is a $ 200 billion market for cleaning up the former East Germany alone. In India also the Pollution Control Boards are seriously implementing pollution control laws and insisting on upgradation of effluents to meet the prescribed standards before they are discharged on land or into a water body. Many companies not complying with the orders have been closed or ordered to shift.

(ii) *Green advocacy:* With increasing emphasis on implementing various Acts and laws related to environment, need for environmental lawyers has emerged, who should be able to plead the cases related to water and air pollution forest, wildlife etc.

(iii) *Green marketing:* While ensuring the quality of products with ISO mark, now there is an increasing emphasis on marketing goods that are environment friendly. Such products have ecomark or ISO 14000 certification. Environmental auditors and environmental managers would be in great demand in the coming years.

(iv) *Green media:* Environmental awareness can be spread amongst masses through mass media like television, radio, newspaper, magazines, hoardings, advertisements etc. for which environmentally educated persons are required.

(v) *Environment consultancy:* Many non- government organizations (NGOs), industries and government bodies are engaging environmental consultants for systematically studying and tackling environment related problems.

1.4 IMPORTANCE OF ENVIRONMENT

Environment belongs to all and is important to all. Whatever be the occupation or age of a person, he will be affected by environment and also he will affect the environment by his deeds. That is why we find an internationally observed environment calender to mark some important aspect or issue 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	Sept. 16–23
World Car-free Day	Sept. 22
Green Consumer Day	Sept. 28
World farm Animal's Day	Oct. 2
World Habitat Day	Oct. 3
World Animal Welfare Day	Oct. 4
Wildlife Week	Oct. 1–7
World Conservation Day	Oct. 24
International Day for Natural Disaster Reduction	Oct. 13
International Day for Biological Diversity	Dec. 29

Global Vs. Local Nature of Environment

Environment is one subject that is actually global as well as local in nature.

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

However, there are some environmental problems which are of localized importance. For dealing with local environmental issues, e.g impact of mining or hydro-electric project in an area, problems of disposal and management of solid waste, river or lake pollution, soil erosion, water logging and salinization of soil, fluorosis problem in local population, arsenic pollution of groundwater etc., we have to think and act locally.

In order to make people aware about those aspects of environment with which they are so intimately associated, it is very important to make every one environmentally educated.

Individualistic Nature of Environment

Environmental studies is very important since it deals with the most mundane problems of life where each individual matters, like dealing with safe and clean drinking water, hygienic living conditions, clean and fresh air, fertile land, healthy food and sustainable development. If we want to live in a clean, healthy, aesthetically beautiful, safe and secure environment for a long time and wish to hand over a clean and safe earth to our children, grandchildren and great grandchildren, it is most essential to understand the basics of environment.

1.5 NEED FOR PUBLIC AWARENESS

International Efforts for Environment

Environmental issues received international attention about 36 years back in Stockholm Conference, held on 5th June, 1972. Since then we celebrate **World Environment**

Day on **5th June.** At the United Nations Conference on **Environment and Development** held at Rio de Janeiro, in 1992, known popularly as **Earth Summit,** and ten years later, the **World Summit on Sustainable Development,** held at Johannesberg in 2002, key issues of global environmental concern were highlighted. Attention of general public was drawn towards the deteriorating environmental conditions all over the world.

Award of the Nobel Peace Prize (2004) to an environmentalist, for the first time, 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

The goals of sustainable development cannot be achieved by any government at its own level until the public has a participatory role in it. Public participation is possible only when the public is aware about the ecological and environmental issues.

The public has to be educated about the fact that if we are degrading our environment we are actually harming our own selves. This is because we are a part of the complex network of environment where every component is linked up. It is all the more important to educate the people that sometimes the adverse impact of environment are not experienced until a threshold is reached. So we may be caught unawares by a disaster.

A drive by the government to ban the littering of polythene cannot be successful until the public understands the environmental implications of the same. The public has to be made aware that by littering polythene, we are not only damaging the environment, but posing serious threat to our health.

There is a Chinese proverb "*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.*" If we want to protect and manage our planet earth on sustainable basis, we have no other option but to make all persons environmentally educated.

1.6 ECOSYSTEMS

Ecosystems of the world are studied on the basis of their principal habitats. Among the environmental segments, lithosphere and hydrosphere are the major habitats for a wide variety of flora and fauna.

Land-based Ecosystem

Land (terrestrial) ecosystems depend largely on the climate and soil. Higher plants and animals have evolved on land. For example, seed plants, insects, warm-blooded vertebrates and micro-organisms dominate on land now. The major terrestrial communities consist of herbaceous plants, shrubs, grass and also woody trees besides numerous insects, arthropods, birds, etc.

Marine Ecosystem

Oceans occupy 70 per cent of earth's surface, offering habitat to numerous plants (mainly algae), animals like zoo plankton, shrimps, oysters, fishes, reptiles, birds and mammals. They serve as the sink of a large quantity of run-off and wastes from land.

Marine water has a high salt content (about 3.5 % by weight) and poor fertility due to lack of nitrates and phosphates as compared to freshwater. Marine life is abundant near the shore and in the continental shelf. The species include commercial fishes, large sea mammals like whales and seals.

Freshwater Ecosystem

Freshwater bodies (ponds, lakes, rivers, springs) are rich in nutrients (nitrates, phosphates) and provide good habitat for phytoplankton, zooplankton, aquatic plants and fishes.

Wetland Ecosystems

Wetlands are transitional lands between terrestrial and eco-systems where water stands at 2.5 to 300 cm during most of the year. They include valuable natural ecosystem harbouring a wide variety of plants, animals, fishes and micro-organisms. They are at present in danger due to increasing urbanization as in the case of eastern part of Kolkata.

Mangroves (Forest between Land and Sea)

Mangroves are important forest communities in tidal zones or equatorial and tropical coasts. For example, the Sunderbans in the Gangetic estuarine delta touching the Bay of Bengal offer important mangroves, habitat of wild animals including Royal Bengal Tiger and of interesting plant species.

1.7 SUSTAINABLE ECOSYSTEM

The developing countries face today critical situation on economic and environmental fronts. For economic growth they have to give priority to agricultural industrial bases but at the cost of environment. The resource base, once depleted, sets in chain of environmental degradation which finally weakens the economy. Our population explosion remains the core issue. Our development policy should be such that the ecosystem is sustainable, i.e., it contains the element of renewability. This requires sound management strategy which ensures the continuation of socio-economic development in the long run.

The important components of sustainable development/ ecosystem are:

- Population stabilisation
- Integrated land use planning
- Conservation of biodiversity
- Air and water pollution control
- Renewable energy resources
- Recycling of wastes and residues
- Environmental education and awareness at all levels.

1.8 HUMAN ACTIVITIES AND ENVIRONMENT

Food: World grain production increased almost three times during the last 50 years. But at the same time population growth increased in the developing or Third World countries at such rate that it surpassed food production. Each year about 40 million people in the developing countries die of malnutrition and starvation. In other words, our food shortage in some areas is killing every year as many people as were killed by the dropping of atom bomb on Hiroshima during World War II.

India is the third largest producer of the staple crops—wheat, rice, maize but about 300 million people are still undernourished (receiving less than 90% of the minimum required calorie intake of 2500 calories/day). Our food crises are directly linked to population explosion (See also Unit-III).

Shelter, Economic and Social Security: India has the lowest man:land ratio—barely 0.48 ha. per capita. It has continuously declined since the 60s. Land is facing too much pressure on various fronts due to increasing population—housing (shelter), agriculture, industry, urbanisation etc. In order to satisfy his needs and greeds for better lifestyle, man has been exploiting the natural resources—forests, water bodies, minerals etc. excessively. This has led to environmental degradation and pollution which, in turn, have threatened his economic and social security and, as a matter of fact, his survival on earth.

B. HUMAN ACTIVITIES AND THEIR IMPACT ON ENVIRONMENT

For economic development and better living, man has sacrificed forest land for agriculture, industries, urbanization etc. This has brought in to trail environmental disaster and backfired on man himself endangering his existence on earth.

1.9 AGRICULTURE

The dawn of human civilization can be traced back to the discovery of agriculture almost 10,000 years ago. In the early period, man used the primitive practice of *slash and born cultivation or shifting cultivation*, which is still prevalent in many tribal areas, as in North East India in the hill regions.

The two modes of agriculture—traditional and modern —are described below along with their impacts.

(i) ***Traditional Agriculture and its Impact:*** It involves small plots, simple tools, natural water, organic fertilizer and several crops. The yield is, however, low but it is still used by about 50% of the world population. The impacts of this type of agriculture are as follows:

(a) *Depletion of Nutrients:* During slash and burn of trees in forests, the organic matter in soil is destroyed and within a short period most of the nutrients are taken up by the crops. Thus the soil becomes deficient in nutrients and compels the cultivators to shift to another area.

(b) *Deforestation:* Forest land is cleared by slash and burn of trees in forest for cultivation purposes. Frequent shifting of cultivation plots leads to deforestation i.e., loss of forest cover.

(c) *Soil Erosion:* As a result of deforestation, soil gets exposed to the weathering forces i.e., rain, wind and storms and is subjected to erosion. The net result is loss of top fertile soil.

(ii) ***Modern Agriculture and its Impact:*** It is based on high input–high *output* technique using hybrid seeds of high-yielding variety and abundant irrigation water, fertilizers and pesticides. This is the basis of "*Green Revolution*" which boosted the production of wheat and India became self-sufficient in food. But

the fallout from Green Revolution has become evident since the 90s (1990) as shown below:

(a) *Impacts from HYV (High-Yielding Varieties):* Application of seeds of HYV gave rise to monoculture i.e., the same species (genotype) grown over vast areas, such monoculture is vulnerable to attack by some pathogen, which spreads like wild fire, devastating crops over large areas.

(b) *Fertilizer Problems:* Essential micronutrients—nitrogen, phosphorus and potassium (NPK) are supplied by chemical fertilizers. Indiscriminate use of chemical fertilizers causes micronutrient imbalance in the soil which ultimately loses productivity.

(c) *Nitrate Pollution:* From agricultural fields nitrogenous fertilizers leach into the soil and finally contaminate groundwater. When the nitrate level of groundwater exceeds 25 mg/l, they can cause a serious health hazard known as *"Blue Baby Syndrome"*, which affects mostly infants even leading to their death.

(d) *Eutrophication:* Agricultural run-off water contains fertilizer components, particularly nitrogen and phosphorus, which reaches nearby waterbodies and causes their overnourishment. Excessive use of these fertilizers leads to overnourishment of the lakes/waterbodies and gives rise to the phenomenon of eutrophication (eu = more, trophication = nutrition).

As a result, there is excessive growth of algal species, which is known as *algal bloom*. The waterbody or lake soon gets filled up with algal species which quickly complete their life cycle and die thus adding a lot of organic matter. Dissolved oxygen in the lake is consumed and fish get killed

so that the lake becomes a dead pool of water devoid of plants and animals. Thus the lake ecosystem gets degraded due to eutrophication.

(e) ***Pesticide Side Effects:*** Several thousand pesticides are used in agriculture for destroying pests and boosting crop production. In the early period of human civilization arsenic, sulphur, lead and mercury were used to kill pests. From 1940 synthetic organic pesticides have been used. Among these, DDT (dichlorodiphenyl trichloroethane), discovered by Paul Mueller (1939), deserves special mention. During 1940-1950, it saved 5 million lives from malaria, typhus etc. and also protected crops from huge losses. But DDT and other pesticides show a number of harmful side-effects on environment.

(a) *Inducing Pest Resistance and Yielding New Pests:* In course of time new generations of pests develop resistance to pesticides so that they survive even after pesticide spray. At present, about two dozen pest species are known to be immune to all types of pesticides.

(b) *Biological Magnification/Amplification:* Many pesticides including DDT are non-biodegradable so that they persist in the food chain. At each step of the food chain the pesticide level gets more and more concentrated. This is the process of biological magnification or amplification. Thus, DDT builds up from 0.04 ppm in plankton to 75 ppm in fish-eating birds. Man occupies a high trophic level in the food chain and hence gets a high dose of pesticide, which is quite harmful.

(iv) ***Waterlogging:*** Excessive irrigation of croplands for good growth of crop leads to waterlogging. In the absence of adequate drainage, excess water is

accumulated which seeps into the underlying water table. Pore spaces in the soil get fully drenched with water and soil-air becomes deficient. The water table rises and the roots of plants have insufficient air for respiration. There is decline in crop yield with decrease in soil strength.

Punjab and Haryana have faced water-logging problems as a result of extensive irrigation by canal water or shallow tubewell water and consequently sharp decline in crop output.

(v) ***Salinity Problem:*** In addition to waterlogging, salinity also rises from excessive irrigation water. The latter contains dissolved salts which under dry conditions evaporates leaving behind salts in the upper soil profile. Saline soils are characterized by accumulation of soluble salts such as sodium chloride, sodium sulphate, calcium chloride, magnesium chloride etc. in the soil profile.

Salinity causes stunted plant growth and reduces crop yield. Thousands of hectares of land in Haryana and Punjab have been affected by soil salinity.

The best method for getting rid of salinity is to flush out by applying freshwater to such soils.

1.10 INDUSTRY

Industries produce environmental hazards everywhere. They consume 37 per cent of world's energy and emit 50 per cent of world's CO_2, 90 per cent of SO_x and almost all the chemicals now threatening O_3 layer with depletion. Every year, they produce 2100 m illion tonnes of solid waste and 350 million tonnes of hazardous waste. In developing countries, small as well as big industries discharge untreated waste.

There is world-wide concern about the disposal of radioactive wastes from nuclear reactors. Nuclear reactor

accidents are expected to increase over the years. The stock of nuclear power stations is also ageing.

In developed countries, industries have enforced economy during the last two decades in the use of resources and energy consumption. It is a common practice for these industries to recycle and reuse water. The average person in a developed country still consumes 15 times more energy than in a poor country. However, in a developed country energy is being used more efficiently and the expected rate of increase of energy consumption is only 1.3 per cent per year.

1.11 TRANSPORT

Transport is a great consumer of land and energy. The length of motor ways has almost doubled in developed countries over the past two decades, reaching 1,500,00 km. in 1990. Transport consumes 30 per cent of world's energy (of which 82 per cent is consumed on roads) and produces 60 per cent CO-emissions, 42 per cent of NO_x and 40 per cent of hydrocarbon emissions.

But there is a hope of new cleaner transport becoming popular in future. Almost one-third of Brazil's cars run on pure ethanol, obtained from specially grown crops and many cars run on ethanol/petrol mixture. Natural gas is being used as a fuel in several countries including Italy where 3 lakh cars run on compressed natural gas (CNG).

Major efforts have been made in developed countries in reducing petrol consumption by 50 per cent of the amount used two decades ago. Auto-emissions have also been cleaned up. Use of lead-free petrol has curtailed Lead (Pb) emission by 87 per cent during 1980-1990.

1.12 MINING

Minerals find extensive use in domestic, agricultural, industrial and commercial sectors and thus form a very important part of any nation's economy.

Minerals are broadly of two types:

(a) Non-metallic minerals e.g., graphite, diamond, quartz, feldspar etc.

(b) Metallic minerals e.g., bauxite, laterite, hematite etc.

Since the early days of human civilization man has used metals extensively. That is why history labelled the eras as Bronze Age and Iron Age. The most abundantly used metals are Iron and Steel (Annual use 750 million tonnes) followed by Manganese, Copper, Chromium, Nickel and Aluminium.

Mining and processing of minerals involve major environmental concerns including disturbance of land, air pollution from dust and smelter emissions and water pollution from disrupted aquifers.

India is the producer of 84 minerals at an estimated annual value of Rs. 50,000 crore. Six major mines are known to cause severe environmental problems.

(a) *Jadugoda Uranium Mine, Jharkhand:* Exposing local area and the population to radioactive hazards.

(b) *Jharia Coal Mines, Jharkhand:* Underground fire causing land subsidence and displacement of people.

(c) *Sukinder Chromite Mine, Orissa:* Seeping of hexavalent chromium into river posing serious health hazard. Chromium Cr^{+6} (hexavalent) is highly toxic.

(d) *Kudremukh Iron Ore Mine, Karnataka:* Causing river pollution and threat to biodiversity.

(e) *East-Coast Bauxite Mine, Orissa:* Land encroachment and rehabilitation issue.

(f) *North-Eastern Coal Fields, Assam:* Very high sulphur contamination of groundwater.

Impacts of Mining: Mining involves extraction of minerals/fossil fuels from deep deposits in soil employing the techniques of sub-surface mining or surface mining. The former method is more dangerous and expensive including risks and accidents. The environmental damages are described as follows:

(a) *Devegetation and Defacing of Landscape:* Large-scale devegetation or deforestation leads to ecological imbalances besides disfiguring the landscape. The huge debris and tailings spoil the environment of the region and make it vulnerable to soil erosion.

(b) *Subsidence of Land:* Underground mining (e.g., coal) causes subsidence of the soil above resulting in tilting of buildings, cracks in soil/road, bending of rail tracks etc.

(c) *Groundwater Contamination:* Mining disturbs the hydrological processes and also pollutes the ground water. Sulphur impurity in many areas gets converted into sulfuric acid through microbial action, which makes the water acidic.

The acid mine drainage often contaminates the nearby streams and lakes and damages aquatic life (plants and fish).

(d) *Air Pollution:* Smelters in metal extraction processes in metallurgical industries emit huge volumes of air pollutants—sulphur oxides, soot, arsenic, lead, cadmium particles etc. These have public health hazards for local residents.

(e) *Occupational Health Hazards:* Most of the miners suffer from various respiratory and skin diseases due to constant exposure to the suspended particulate matter and toxic substances. Such diseases include asthma, bronchitis, black-lung disease, asbestosis, silicosis etc.

1.13 ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

The inherent conflict between development and environment can be solved to a great extent by a sound environmental management plan which is based on balancing development with environment. The necessary tool for this is *Environmental Impact Assessment* (EIA). Development should not be treated as an economic goal but as a multi-

dimensional concept covering economic as well as political, social and cultural aspects of life of common man.

The basic objective of EIA is to identify, predict and evaluate the probable economic, environmental and social impacts of developmental activities and take necessary steps as remedial measures which will be a part of the overall environmental management plan (EMP).

It is the government's policy that any industrial project particularly major industry must obtain EIA clearance from the ministry of environment before approval by the planning commission. It may be mentioned that EIA is conducted by a team of experts in the field (environment), appointed by the Ministry of Environment, Government of India.

1.14 SUSTAINABLE DEVELOPMENT

As per the definition of the then director of World Health Organization (WHO), Prime Minister G.H. Bruntland (Norway), sustainable development means *"meeting the needs of the present without compromising the ability of future generations to meet their needs"*! Nowadays sustainable development is the keynote of many projects but only few of them achieve sustainable growth.

Overexploitation of natural resources, particularly by the developed countries, since 1970s is fast heading towards unsustainable growth and collapse of our life-support base. In 1992, the UN Conference on Environment and Development (UNCED) was held at Rio de Janeiro, Brazil. The Rio declaration on Agenda-21 adopts a global programme of action on sustainable development in social, economic and political contexts for the 21st century.

The important components of sustainable development are:

- Population stabilization (growth below 0.5 per cent)
- Integrated land-use planning
- Conservation of biodiversity

- Air and water pollution control
- Renewable energy resources
- Recycling of wastes and residues
- Environmental education and awareness at all levels

Questions

1. What is meant by
   (a) Environment?
   (b) Environmental studies?
2. What do you mean by ecosystem?
3. Illustrate land ecosystem and also aquatic ecosystem.
4. Classify the ecosystems on the basis of their habitats. Give examples.
5. What is sustainable ecosystem?
6. Give a short account of the impacts of agriculture on environment.
7. What is meant by
   (a) Eutrophication?
   (b) Waterlogging?
   (c) Salinity of soil?
8. Enumerate the impacts of mining.
9. What is the significance of sustainable development? What are its main components?

Unit-II

A. Natural Resources

Nature provides life support materials or resources for sustenance of life on earth for plants, animals and man. These resources are known as **Natural Resources**. Examples are water, air, soil, forests, minerals, crops etc.

There are two categories of natural resources:

1. *Renewable Resources:* These can be recycled and regenerated within a given span of time e.g., forests, wind energy, solar energy, biomass energy, hydropower etc.
2. *Non-renewable Resources:* These cannot be regenerated e.g., fossil fuels such as coal, petroleum, minerals etc. With increase in consumption, these will be exhausted in near future.

It must be noted that even renewable resources are endangered and liable to extinction if these are exploited recklessly e.g., forests.

The major natural resources are:

(i) Forest resources
(ii) Water resources
(iii) Mineral resources
(iv) Food resources
(v) Energy resources
(vi) Land resources.

2.1 FOREST RESOURCES

Forests are one of the most important natural resources on earth. Providing the earth with a green cover, the forests also offer several environmental services which are essential for sustenance of life.

About 33% of the world's land area is under forest cover. Former USSR (now CIS) accounts for about 20% of the world's forests, Brazil for about 15% and Canada and USA, 6-7%. But over the years the forest cover has been reduced due to reckless deforestation by man almost all over the world, particularly in tropical Asia.

Forest Resources/Wealth

Plants have been dominating the earth for about 3.0 billion years. They have the unique art of manufacturing their own food by photosynthesis from nature and the rest of the living world depends on them for their food and sustenance. Plants constitute 99 per cent of earth's living species and the rest 1 per cent include animals and man who depend on the plant world for their food. If this ratio (99:1) is disturbed by elimination of plants (i.e., deforestation), then the natural balance will be lost and the entire living world will suffer most. This dynamic balance is among plants (*producers*), bacteria and micro-organisms (*decomposers* who decompose mineral salts in soil into elements which are cycled back into plants) and animals plus man (*consumers*). Once this dynamic balance is upset, there would be ecological crisis and the entire biosphere would be in danger.

Forests are renewable resources and have a key role in improving the quality of environment by exerting beneficial effect on the life support system. Moreover, forests also contribute much to the economic development of the country by providing goods and services to people and industry. They are the treasure house of valuable plant and animal genes

and medicinal plants, most of which are yet to be discovered. Hence tropical forests, in particular, are regarded as bioreserves. Our ancient civilisation flourished in forests, where Indian philosophy was built up by our "rishis" (seers).

It is well-known that forests play a vital role in the life and economy of all forest-dwelling tribes. They supply food (tuber, roots, leaves, fruits and meat from animals and birds), medicinal herbs and other forest products for commercial use which provides for forest-based subsistence.

Around 3000 BC, India had about 80 per cent forest cover. During the Maurya period of history emperor Chandra Gupta Maurya and later his grandson Ashoka adopted the policy of tree-plantation. Emperor Ashoka also ordered the establishment of the first *wildlife sanctuaries* (*abhayaranyas*). Carvings on stone pillars from this era show how wild animals were treated with medicine and care.[1]

But waves of migrants came to India from middle-east countries which were deserts and tree-less and they changed the whole landscape. During the Moghul period again the picture was reversed as the Moghuls came from tree-less countries—they converted forests into agricultural lands. During the British period, the rate of forest conversion into agricultural land continued. They also exploited forests for timber for laying communication system, particularly after 1867 (India's First War of Independence/Sepoy Mutiny). After our independence in 1947, the situation did not improve rather the trend continued to draw revenue from forests. The net result is that the forest cover has dwindled from 80 per cent to about 12 per cent in 5000 years. India has been losing 1.3 million hectares (1 ha = 2.5 acres) of forests each year.

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[1] *Big hunting game by Hindu kings in the earlier periods had caused destruction of wildlife and forests.*

The main causes for forest destruction are human population and livestock (cattle, buffaloes, goats, sheep) population explosion. These enhance the demand for timber and fuel wood (for man) and grazing land (for livestock). At the global level wood consumption is 46 per cent for industrial and 54 per cent for firewood purposes. In developing countries like India the picture is reverse—82 per cent for firewood and 18 per cent for industrial purpose. The present requirements in India (in 2000) are—78 per cent for fuel wood, 16 per cent for timber and 6 per cent for pulpwood (for paper industry).

2.1.1 Forest Conservation

The Forest Policy of the Government of India (1952) laid down that one-third (33 per cent) of our land should be under forest cover. However, this has not been followed seriously with the result that the present forest cover has gone down to about 12 per cent. We have almost reached a critical state which must be remedied now before it is too late for our own survival. The remedial measures (conservation) have been suggested as follows:

(i) *Conservation of Reserve Forests*: These are areas where our major water resources are located, viz. the Himalayas, Western and Eastern Ghats and areas like reservoirs, National Parks, Sanctuaries, Biosphere Reserves, etc. These must be protected and no commercial exploitation be allowed in these areas. This is an important conservation strategy.

(ii) *Limited Production Forests*: These are less fertile areas at high altitude (more than 1000 metres) with hilly environment. Here the health of the forests should not be damaged and only limited harvesting with utmost care be allowed.

(iii) *Production Forests*: These are forests on the plains and their productivity can be enhanced by proper management. These should be maintained to make up for the losing of forest cover.

(iv) *Social/Commercial Forestry*: Such forestry is meant for supplying goods and services to meet the ever-increasing demand for firewood, fodder, food, fertiliser, fibre, timber, medicine, etc. or for industrial purposes such as timber, plywood, matchwood, fibre board, paper and pulp, rayon, etc. The main idea is to remove pressure on natural forests for these requirements.

Social forestry is based on public and common land (private) to produce firewood, fodder, fruit and small timber for rural people.

The programme should be conducted by a co-operative system including farmers, tribals, panchayats and NGOs (non-government organisations), etc. Degraded lands should be utilised for social forestry for firewood, whereby the quality of land improves in course of time.

Massive afforestation should be done involving multi-purpose species of plants/shrubs so that every village/town/city is able to meet its requirements for firewood, fodder and small timber. Production/Commercial Forestry is intended entirely for commercial purposes to meet the needs of the forest-based industry. Fallow lands, not used for agriculture, grazing lands, etc. can be used for raising such plantations.

2.1.2 Wood —A Major Renewable Resource

Wood is a major renewable natural resource. In USA, the production of wood and wood products is the fifth largest industry. Wood ranks first as a raw material for the manufacture of other products. Ideally, forests should cover one-third of the land area.

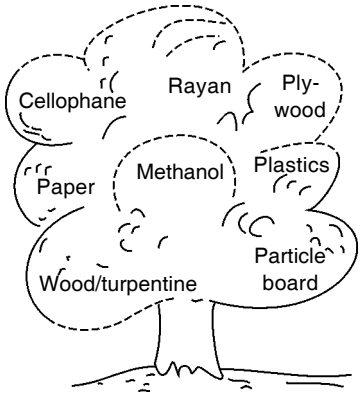


Fig. 2.1: *Many important products come from trees*

2.1.3 Biodiversity

There may be about 10 million species of plants, micro-organisms and animals on earth while only about 1.5 million species are on record, i.e., identified so far. Among these the majority are insects (7,50,000), 41,000 are vertebrates (i.e., those having backbones or spinal columns), 2,50,000 are plants, 1,00,000 are fungi and the rest are invertebrates and micro-organisms.

Biological diversity or biodiversity involves genetic diversity among species as also between individuals and ecological diversity, i.e., number of species in a community of organisms. The existing species of plants and animals are the product of 3-billion years of evolution involving mutation, recombination and natural selection. Changes in environment, e.g., warm and cool periods exerted selection pressures and have been responsible for evolution of new species and extinction of others who could not survive in the struggle for survival. The dinosaur era is an example. These giant-sized animals dominated the earth for 130 million years and became extinct before the Ice Age.

Natural extinction, part of evolutionary process, has been accelerated by man-made extinction wave due to constant

greed and need of man. By this time, 1 out of 10 million species has become extinct and each day we are losing one plant and one animal species. At this rate of extinction, the survival of man himself is threatened. The *specide* (extinction of species) in which man is involved is more serious a crime than genocide (mass murder). In this context we may note our tradition. Charak, the well-known ancient physician, was asked by his teacher to get a plant that was useless. He returned after a few days and reported that there was no such plant. One cannot imagine a situation if *Penicillium* was extinct before man could make use of it as an antibiotic or if *Cinchona* became extinct before quinine was discovered as a cure for malaria. It is, therefore, in our own interest that we should conserve our plant as well as animal and micro-organism (fungus and bacteria) wealth. There is a growing realisation all over the world about the urgent need to conserve the *biological diversity*.

The United Nations Earth Summit (Rio de Janeiro, 1992) adopted the Treaty on Biodiversity whereby countries agreed to conserve the Biodiversity—the living natural resources (plants, animals, microbes) for the welfare of mankind.

2.2 WATER RESOURCES AND WATER USES

Man is using petroleum for more than a century extensively and coal for several centuries. Human civilisation spent 99.9 per cent of time without these fuels. The world's petroleum stock is likely to be exhausted in another hundred years and coal in a few centuries. This will pose a crisis before mankind. But when we realise that our usable water resources is also limited and will be out of stock in near future, then we indeed have cause for panic.

Water has no alternative—it is known as "*life*". It is essential for the sustenance of all living organisms including plants, animals and man. All plants, insects, animals and men have 60–95 per cent water in their bodies. This water is partly

released in the form of sweat, excreta, urine and vapour. So all these species require a lot of water daily. Besides, much water is also needed for body growth, nutrition, etc. So it is absurd to think of life without water. But our usable water resources like any other natural resource is finite and is likely to be exhausted within a century. Moreover, it is getting polluted by man-made activities and unfit for use sooner than expected. Water crisis is more serious than food or population crisis since food production or population problems are irrelevant without water supply. Use of polluted water itself takes toll of 25,000 people all over the world every day. In India, out of 6 lakh villages, one-third or about 2 lakh villages are without access to water. In these villages, women have to walk daily about 1–14 km to collect water for cooking and drinking. The United Nations Food and Agriculture Department estimates that if the present day practices of wasting and polluting water are not stopped, then within less than a century the world's biosphere including man will disappear.

> The world's total quantum of water is 1.4 billion cubic kilometre. If all the seabeds could be filled up and brought at the level of the earth's surface, then the entire water in the seas would cover the earth's surface and make it 2.5 km deep watermass. *About 97 per cent 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 per cent, 2.3 per cent is locked in the polar ice caps and hence out of bounds. The balance 0.7 per cent is available as freshwater but the bulk of it, 0.66 per cent, is groundwater and the rest 0.03 per cent is available to us as freshwater in rivers, lakes and streams.* The break-up of this 0.03 per cent freshwater is—lakes and ponds 0.01

per cent, water vapour 0.001 per cent, rivers 0.0003 per cent and water confined in plants, animals and chemicals 0.0187 per cent.

[The United Nations Water Conference Report, Argentina (1977)]

Thus we see that we have a very limited stock of usable water, 0.03 per cent surface water (rivers, streams and ponds) and 0.66 per cent groundwater. The quantity of water vapour arising from evaporation of sea water and river water returns by the same volume to the earth's surface by rainfall and back to the water sources. The hydrological cycle in nature is more or less balanced in terms of charge (cloud formation) and discharge (rainfall). But we are drawing large quantities of groundwater for agriculture and industries while the waste water from these is much polluted and on mixing with rivers is polluting the rivers also.

The mass balance of annual rainfall shows that about 70 per cent is lost by evaporation and transpiration by plants, while the remaining 30 per cent goes into the stream flow. The approximate break-up of this stream flow, as consumed by man is—8 per cent for irrigation, 2 per cent for domestic use, 4 per cent for industries and 12 per cent for electrical utilities. Irrigation for agriculture and electric power plants are the major consumers of water.

These waste liquids (effluents) can be purified by filtration using activated charcoal or ion exchange resins. Activated charcoal has large surface area and is an effective filter medium for adsorption of organic molecules. Synthetic organic ion exchange resins are very useful for the removal of industrial waste metals (cations) and non-metals (anions).

Water Quality

It is essential to enforce water quality standards in the interest of public health. All developed countries strictly conform to water quality standards. Polluted water generates

water-borne diseases which kill millions of people every year all over the world, particularly in developing countries. The United States Public Health (USPH) has laid down standards for water quality parameters (indicators) for drinking water. These are the upper limits in parts per million (ppm) (1 ppm = 1 in 10^6 parts).

Table 2.1. *Water quality parameters (domestic water supplies) USPH standards (upper limits)*

Parameters	***(in ppm, except for pH)***
pH	6.0–8.5
Dissolved oxygen (D.O.)	4.0–6.0
Total dissolved solid	500.0
Suspended solid	5.0
Chloride	250.0
Sulphate	250.0
Cyanide	0.05
Nitrate + Nitrite	10.0
Ammonia	0.5
Calcium	100.0
Magnesium	30.0
Iron	0.3
Lead	0.05
Mercury	0.002
Arsenic	0.05
Chromium (VI)	0.05
Zinc	5.5
Phenol	0.001
Chemical Oxygen Demand (COD)	4.0

All parameters except pH are in ppm.
1 ppm = 1 in 10^6 parts

The parameters for surface water (rivers, lakes, etc.) are 4–5 times higher than the above values for drinking water.

Clean water is essential for healthy environment to support life systems on this planet. The task of delicately balancing the ratio of available and exploitable water

resources and sustaining their quality is most important for India as rainfall distribution is confined to 3–4 months in a year. Moreover, man-made global and local climatic distortions due to global warming (*see* Chapter 6), deforestation, loss of topsoil, etc. have adverse effect on the monsoon pattern in India.

India is blessed with good rainfall (average 200 cm in a year) but 70 per cent of it is wasted. The country faces recurring problems of floods, and droughts and highly polluted water resources. It is necessary to do rain harvesting, i.e., build large tanks and reservoirs all over the country to store rain water, flood water and excess water from the Ganga, Brahmaputra and other rivers. The rivers, the lifelines of our culture and economy, are dying because of severe pollution. This water pollution abatement and resource management should be at the top of our national agenda.

2.3 WATER-BORNE DISEASES

The names of common water-borne diseases are given in Table 3.6: p. 90. The causative agents for water-borne diseases may be virus, bacteria, protozoa or helminths. The diseases like viral hepatitis (hepatitis A, hepatitis B), poliomyelitis and diarrhoea are caused by virus. The diseases like cholera, bacillary dysentery, typhoid and paratyphoid are caused by bacteria and the diseases like amoebiasis, giardiasis are caused by protozoa. Some common water-borne diseases are discussed in detail in the following section.

Cholera

This is a highly contagious disease (water-borne and food-borne), caused by the bacteria, *Vibrio cholerae*. Typical symptoms are diarrhoea with rice water stool, vomitting, rapid dehydration, muscular cramps and anuria. In severe case, acute renal failure is possible. Epidemics of cholera had occurred in the past in India during Kumbha Mela or Ardha-

Kumbha Mela. Outbreaks of cholera were also reported in the past from Maharashtra, Tamil Nadu, Andhra Pradesh, Karnataka, Bihar, Orissa and West Bengal.

The bacteriology of cholera is complicated. *Vibrio eltor* replaced the classical *V. cholrae* by the end of 1965. Most of the Eltor vibrios isolated were found to belong to the serotype Ogawa. *V. cholerae* are gram-negative, comma-shaped, actively motile organisms. The Eltor vibrios resemble the true cholera vibrios morphologically, serologically and also biochemically.

Factors for Spread of Cholera

Environmental Factors: Among environmental factors, water, food and flies play important role in spreading cholera in the community. Cholera vibrios do not multiply in water but they may survive up to two depending on temperature, pH, salt content, organic matter, sunlight and other factors. In our country there are a large number of uncontrolled water supplies (e.g., polluted river, ponds, canals, etc.) which are major sources of cholera infection. Cholera vibrios can multiply readily in certain foods and drinks like milk, milk products and some varieties of boiled rice. Fruits and vegetables get contaminated when washed or sprinkled with water from infected areas.

Social Factors: Big fairs like Kumbha Mela or Ardha Kumbha Mela where lakhs of people assemble at the river ghats are one of the most important factors for the spread of cholera. The crowd bathe and drinking the same river water (Ganga) rapidly spread the disease. Cholera is a disease of the poor people who come from low income groups, live in slums under unhygienic and inhuman conditions. They participate in these melas and contaminate the river water.

Control of Cholera

The control of cholera can be achieved by early detection of the disease, isolation of the patients and their prompt treatment, improvement of sanitary facilities along with

adequate supply of safe drinking water to the community. Active immunisation and health awareness are also the important measures for cholera control.

For early detection, bacteriological examination of stools is required for confirmation of the disease. The disease should at once be notified to the local authority who will send the information to the State Health Authority and finally to the Central Health Authority.

The treatment of cholera consists of rehydration and antibiotics. Rehydration saves life. In case of kidney failure, *dialysis* is required. The rehydration should be accomplished either by injecting intravenous solutions of saline (consisting of sodium chloride: sodium bicarbonate: potassium chloride = 5:4:1) or by giving oral fluid containing a mixture of sodium chloride, sodium bicarbonate, potassium chloride and glucose in the ratio of 3.5:2.5::1.5:20 gm. dissolved in 1-litre water. Tetracycline and co-trimoxazole should be administered as antibiotic.

Improvement of sanitation for the entire community and their residential area is the most effective approach for the prevention and control of cholera. Provision for sanitary latrine for every household is essential for checking the incidence of cholera. Water to be used for domestic purposes, viz. drinking, washing, cooking, cleaning utensils, etc. from sources such as rivers, ponds, lakes, canals, etc. should be boiled. The provision of safe drinking water for all is the permanent solution as it will minimise the incidence of cholera. It is also necessary to observe the rules of hygiene rigorously—household pests, flies, cockroaches, etc. should be eliminated; cut fruits and vegetables which are exposed to dust and flies in open markets should be avoided.

Amoebiasis

This is a water-borne disease, defined by WHO as the condition of harbouring *Entamoeba histolytica* with or without

clinical manifestations. It has world-wide distribution. The disease is characterised by liquid stools with mucous and blood.

E. histolytica are found as cysts or motile trophozoites. They can live outside the human body as *cysts*. Trophozoites cause ulcer in the large intestine. Some amoebas reach liver through portal vein any may cause hepatitis or abscess. Intestinal and hepatic amoebiasis are the main manifestations of the disease.

The cysts can live for several weeks outside the human body, if kept moist and cool. In a refrigerator, they can live in water for 6–7 weeks. They do not survive at moderate temperature, e.g., 50°C.

Man gets the infection through food chain (cut fruits, salads, vegetables, contaminated drinking water, cold drink, etc.). Uncooked food and vegetable can be disinfected by washing with iodine solution (200 ppm) or acetic acid (5–10 per cent) or vinegar. From water, cysts can be removed by *filtration* and *boiling*. The cysts in milk can be killed by pasteurisation. The diagnosis is usually based on the detection of *Entamoeba histolytica* in the stools.

The antibody of the parasite can be easily detected by Immuno-fluorescence method.

Prevention of Amoebiasis

The disease can be prevented by

(i) sanitary disposal of human excreta.

(ii) provision of safe drinking water to all (water should be boiled and filtered before drinking).

(iii) hygienic kitchen practice (uncooked fruits and vegetables must be thoroughly washed or disinfected as described before.

(iv) protection of foods against flies.

Treatment

The drugs usually prescribed by physicians are:

1. Metronidazole (400–800 mg) (Flagyl) to be taken one tablet thrice a day for 5–7 days.
2. Entrozyme (250 mg)—one tablet thrice a day for 7 days
3. Trinidazole (1–2 gm)—one tablet for 3 days
4. Furamide (500 mg)—one tablet thrice a day for 10 days.

Fluorosis

Fluoride in diet or drinking water above 1.5 ppm causes fluorosis. The maximum tolerance level in human body is 1.5 ppm (WHO standard). The daily intake of F from food and drinking water is usually less than 1 ppm. Some parts of south India and South Africa have reported fluoride concentrations of 4 to 8 ppm. In India, some 25 million people spread over 100 districts in 15 states suffer from fluorosis. These affected states are Andhra Pradesh, Bihar, Delhi, Gujarat, Haryana, Karnataka, Maharashtra, Madhya Pradesh, Orissa, Punjab, Rajasthan, Tamil Nadu, U.P., West Bengal and Kerala.

Fluoride does not concentrate in any tissue but only in the bones and teeth. Fluorosis affects bones, teeth, tissues and other organs of the body, leading to death after prolonged illness. It also leads to dental decoloration and deformation of bones causing knock knees, bow legs and stiffening of the joints, joint pains, back pain etc. In endemic areas, large percentage of people suffer from gastrointestinal complaints, diarrhoea etc. The expectant and lactating mothers are vulnerable groups—there is high incidence of stillbirths and abortions.

Provision of safe drinking water (1-ppm fluoride) and creating awareness among people of the dangers of fluorosis are the urgent needs of the hour for prevention of fluorosis.

2.4 MINERAL RESOURCES

Mining and processing of minerals/ores involve major environmental concerns, including disturbance of land, air

pollution from dust and smelter emission, and water pollution from disrupted aquifers.

The rate of depletion of resources is measured by two parameters—*per capita* mining and *per capita* consumption. Per capita mining is calculated by dividing the amount of resource mined by the population. Per capita consumption is obtained by dividing the amount of resource actually processed by the population. It is a better index of the standard of living of the population. Table 3.2 lists the world's mineral reserves along with the per capita mining and consumption figures on a global basis.

Table 2.2. *World's mineral reserves: per capita mining and consumption*

Resources	*Reserve (tonnes)*	*Occurring as mining (kg)*	*Per capita consumption (kg)*	*Per capita*
1	2	3	4	5
Al	1.1×10^9	Al_2O_3, nH_2O	15.1	2.8
Sb	$3.6 \times 10_6$	Sb_2S_3	14.8 g	17.3 g
Asbestos	—	—	1.0	0.9
Cr	4.4×10^9	Fe Cr_2O_4	0.7	0.5
Coal	4.7×10^{12}	—	580	624
Co	2.2×10^6	$CuCO_2$ S_4, CaS_2	—	5.6g
Cu	280×10^6	Cu FeS_2 Cu_2S	1.6	1.5
Au	11×10^3	Au	0.4 g	0.4 g
Fe	88×10^9	Fe_2,O_3, Fe_3O_4	110	1.9
Pb	82×10^6	PbS, $PbCO_3$	3.8	0.8
Mn	635×10^6	MnO_2, $Mn_2O_3 \cdot H_2O$	2.0	2.2
Hg	115×10^3	HgS, Hg	2.6 g	2.2 g
Mo	5.2×10^6	MoS_2	20.7 g	18.7 g
Ni	68×10^6	(Fe, Ni) S	145 g	135 g
Petroleum	54.1×10^9	—	582	471
Phosphate	19.8×10^9	$Ca_5(PO_4)_3$ (F, Cl, OH)	23	3.2
Potash	99.9×10^9	KCl, $KMgCl_2.6H_2O$	4.6	3.6
Ag	$171/10^3$	Ag, Ag_2S, Ag_3, AgS_3	—	—
Ti	310×10^6	SnO_2	50.6 g	70.5
W	3×10^6	$CaWO_4$, (Fe, Mn) WO_4	—	—
U	749×10^3	U_2O_8	—	4.8 g
Zn	112×10^6	ZnS, ZnO	1.5	1.4

US Bureau of Mines "Mineral facts and problems", 1970; UN Statistical Yearbook, 1970.

Although quantitative in nature, the figures in the table show some interesting trends. The world per capita mining figures indicate that five minerals are mined to the maximum extent—coal, petroleum iron ore, aluminium and phosphate rock. However, the demand on resources is not equitably distributed over the entire population. This is reflected in the contrast between the per capita mining figures for the Asian and North American subcontinents. This disparity is further aggravated by the fact that USA, for example, imports substantial quantities of most of the resource so that its per capita consumption figure exceeds its per capita mining figure.

As far as metal resources are concerned, they may be grouped under two heads: non-ferrous (base and precious) metals and ferrous metals plus Aluminium.

	Average reserve	***Av. per capita consumption***
Group 1: Metals (non-ferrous)	0.05×10^9 tonnes	0.42 kg
Group 2: Metals (ferrous + 4)	11.8×10^9 tonnes	14.4 kg
Ratio: Group 2/Group 1	210/1	34/1

The Group 1 metals are: Au, Hg, Sn, Ag, Zn, Pb, W, U, Cu, and Sb whereas the Group 2 metals are: Mo, Mn, Al, Co, Ni, Ti, Fe, Cr and K.

Non-metal Resources

The major non-metal resources include asbestos, carbonates, Cl_2, granite, O_2, phosphate, potash, sand and gravel, Na compounds and H_2O.

Asbestos (silicate minerals), the carbonates—principally those of Ca and Mg—sand and gravel, together with granite, constitue the common and most widely used building materials. As in the case of metals, the environmental aspects of many of these minerals are quite important.

2.5 NATURAL/BIOGEOCHEMICAL CYCLES

Within an ecosystem (*see* next Chapter) there are dynamic relations between the living forms and their physical

environment, i.e., rocks, air and soil of the earth (geo-). These relations are found as natural or biogeochemical cycles which involve continuous circulation of the essential elements and compounds required for life from environment to organisms and back to environment. The natural cycles and ecosystems function in a balanced manner which stabilises biosphere and sustains the life processes on earth.

2.5.1 The Hydrological Cycle

This cycle helps in the exchange of water among air, land, sea, living plants and animals. About one-third of the solar energy absorbed by the earth is used to drive the hydrological cycle—massive evaporation of water from the oceans, cloud formation and rainfall which supplies our reserves with freshwater.

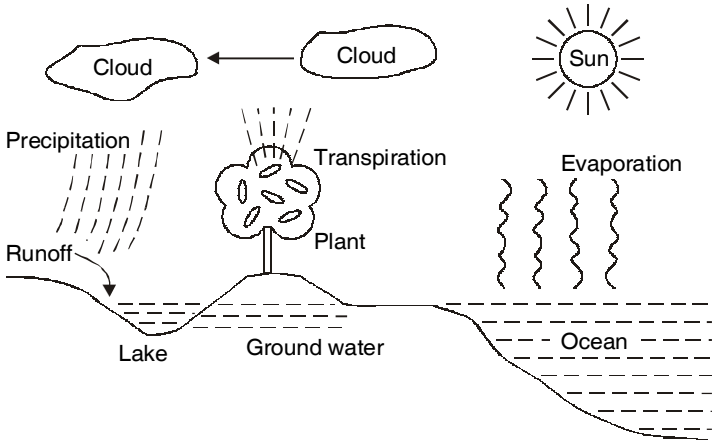


Fig. 2.2: *The hydrological cycle*

At freezing temperature rainwater freezes into snow and forms hail in the presence of strong wind. Water as rain, snow and hail is precipitated on land and water surfaces. On land surfaces water seeps into the soil and is stored as groundwater. The natural water level or water table exists below the ground.

The water table is supported by the underlying clay and rock strata. Groundwater does not remain static but moves in various directions. It moves up and reaches soil surface where it is drawn by plant roots.

Another important groundwater resource is the aquifers. These exist above the impermeable rock strata—water percolates through porous rocks and forms these underground lakes or reservoirs. From the latter water can be pumped by digging tube wells and extracted by sinking wells.

When there is good rainfall, all the rainwater on land do not percolate into the soil. Surface water (run-off) flows into streams, rivers, seas, lakes and reservoirs. Normal evaporation from the oceans exceeds precipitation by 10 per cent. This excess 10 per cent moves as water vapour over land surface and balances the hydrological cycle. Plants absorb groundwater by root pressure and transpirational pull but give off excess water through leaves by the process of *transpiration*. Thus, water vapour level in the atmosphere is balanced and at the same time ensures conduction of water and dissolved mineral salts throughout the plants.

Thus, the hydrologic cycle consists of a balanced continuous process of evaporation, transpiration, precipitation, surface run-off and groundwater movements.

2.5.2 Nitrogen Cycle

Nitrogen and its compounds are essential for life processes in the biosphere. There is continuous exchange of nitrogen within the ecosystems operating the nitrogen cycle. Proteins produced by plants and animals in their metabolic processes are organic compounds of nitrogen. The major load of nitrogenous organic residue in soil originates from death and decay of plants and excreta of animals. These organic residues in soil are taken up by various soil micro-organisms for their metabolism which give products such as ammonia, nitrates

and nitrites. Plants absorb nitrates from soil which re-enter the nitrogen cycle. Some soil micro-organisms break down soil nitrate into nitrogen by denitrification process while others transform nitrogen into soluble nitrogen compounds (*see* Fig. 2.3).

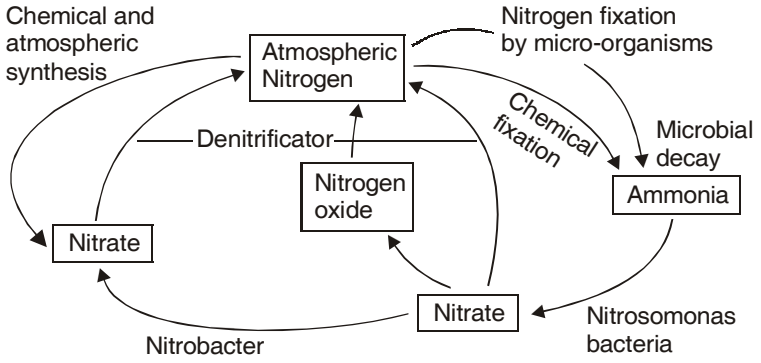


Fig. 2.3: *The nitrogen cycle*

2.5.3 Carbon Cycle

As carbon is the backbone of biological chemistry, the carbon cycle is a very important chemical cycle. The atmosphere is the minor reservoir of carbon dioxide while the oceans are the major reservoir, containing as much as 50 times more as that of air where it is stored as bicarbonate mineral deposit on the ocean floor. The latter regulates the carbon dioxide level in the atmosphere. The cycle operates in the form of carbon dioxide exchanging among the atmosphere, biosphere and the oceans (Fig. 2.4). The Carbon dioxide balance sheet per year is given:

(i) emissions by fossil fuel 20 billion tonnes,

(ii) emissions by deforestation and changes in land use 5.5 billion tonnes,

(iii) uptake in the oceans 5.5 billion tonnes,

(iv) uptake by carbon dioxide fertilization, i.e., photo-synthesis, 7.3 billion tonnes.

Thus there is a net increase of carbon dioxide in the atmosphere of 11 billion tonnes per year. This can be reduced by 50 per cent if we can stop deforestation (Fig. 2.5).

The atmosphere contains 2700 billion tonnes of carbon dioxide; biosphere, vegetation and soil about 6600 billion tonnes and the oceans about 1,36,000 billion tonnes of carbon dioxide.

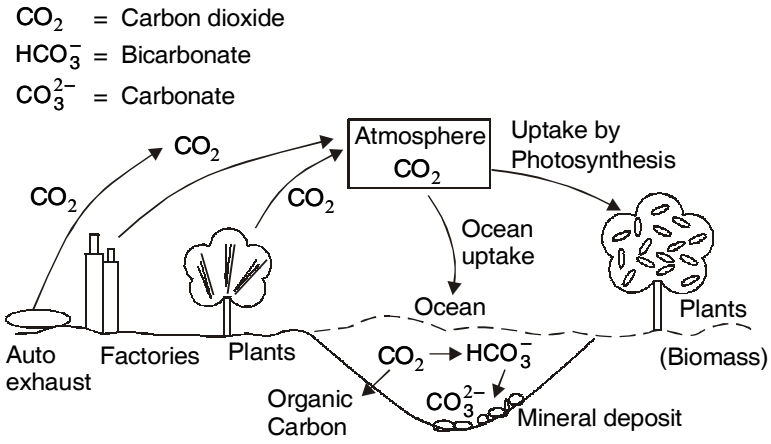


Fig. 2.4: *Sources and sinks of carbon dioxide*

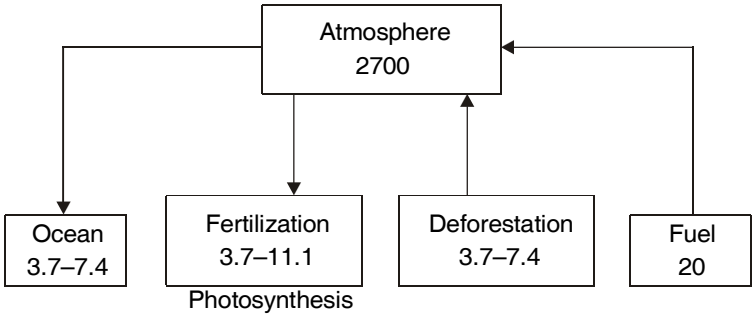


Fig. 2.5: *Important fluxes of carbon dioxide (in billion tonnes)*

2.5.4 Phosphate Cycle

Phosphates are necessary for the growth and maintenance of animal and human bones and teeth while organo-phosphates are required for cell division involving production of nuclear DNA (deoxyribonucleic acid) and RNA (ribonucleic acid).

Phosphate minerals exist in soluble and insoluble forms in rocks and soil. Plants absorb inorganic phosphate salts from soil and change them into organic phosphate. Animals obtain their phosphate by eating plants. After death and decay, plants and animals return phosphates to the soil. Bulk of the phosphate in soil is fixed or absorbed on soil particles but part of it is leached out into waterbodies.

The natural phosphate cycle is affected by pollution, mainly from agricultural run-off containing superphosphate and also from domestic sewage. Phosphate pollution of rivers and lakes is the cause of algal bloom (eutrophication) which reduces dissolved oxygen in water and disrupts the food chain. The phosphate cycles on land and in water are shown in Figs. 2.6 and 2.7.

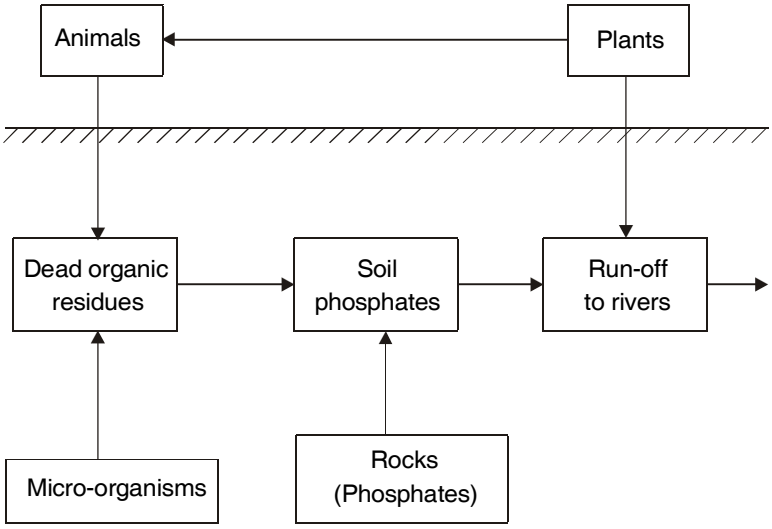


Fig. 2.6: *The phosphate cycle on land*

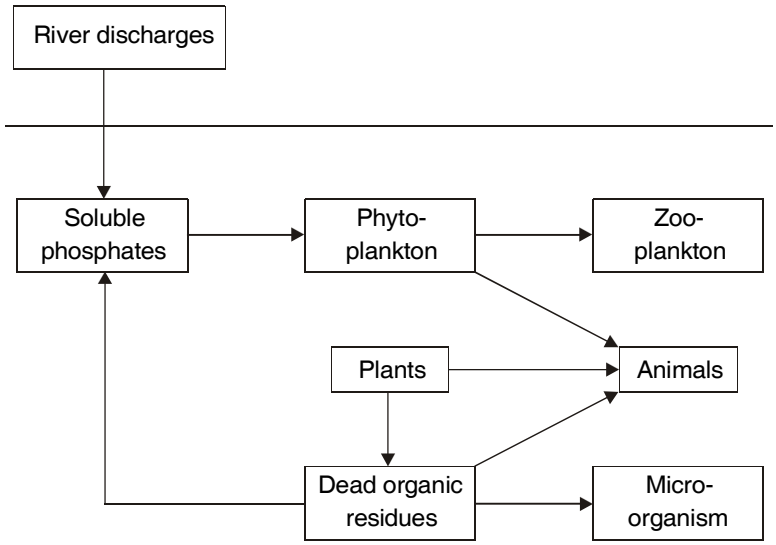


Fig. 2.7: *The phosphate cycle in water*

2.5.5 Sulphur Cycle

Sulphur and its compounds are required by plants and animals for synthesis of some amino acids and proteins. Some sulphur bacteria act as the media for exchanges of sulphur within the ecosystems. The sulphur cycle (Fig. 2.8) illustrates the circulation of sulphur and its compounds in the environment.

The sulphur oxidation process is shown in the upper half of the cycle. The lower section shows the conversion of sulphate into plant and cellular proteins and the decay of dead plant and animal material by bacterial action. In polluted waters under anaerobic conditions hydrogen sulphide is produced by bacteria giving deposits of iron sulphide. In unpolluted waters under aerobic conditions the sulphur bacteria transform sulphides into sulphates for further production of proteins.

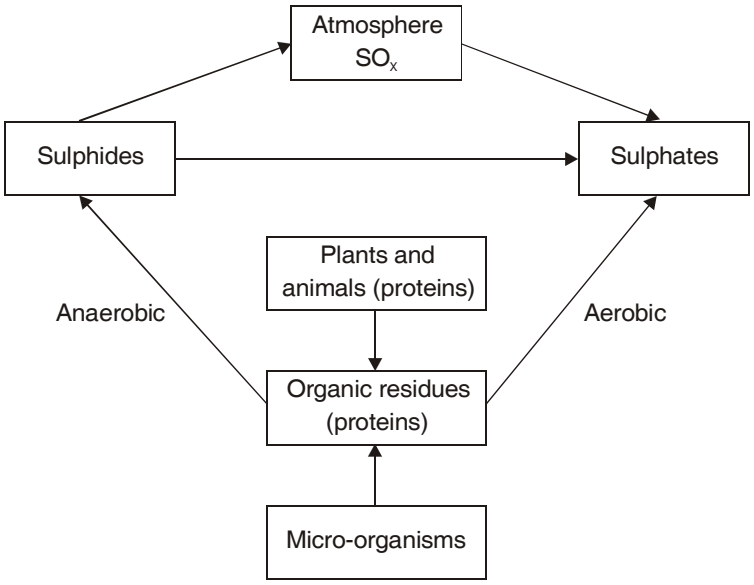


Fig. 2.8: *The sulphur cycle*

B. ENERGY

2.6 CONVENTIONAL ENERGY RESOURCES

The invention of steam engine in 1780 brought about Industrial Revolution in Britain. In 1799, Volta invented the *battery,* the first source of electric current. In 1820, Michael Faraday demonstrated a device—dynamo, for production of electricity using "dynamo" (electro-magnetic induction). Electricity generation using heat of steam marked the beginning of thermal power production in the middle of 19th century.

The demands on energy are increasing with progress in human civilization. The quality of life or standard of living is linked with the quantum of energy consumption. In USA,

per capita energy consumption is 200 million British Thermal Units, BTU (1 BTU = energy required to raise the temperature of 1 lb. of water by 1°F), 125 million BTU in UK, 50 million BTU in Japan and only 5 million BTU in India. But generally much of the energy (about 60 per cent) is wasted. Maximum wastage is observed in power plants and vehicles.

The conventional energy resources are fossil fuel (coal, petroleum and diesel), wood, natural gas, hydroelectricity and nuclear energy. The energy, as consumed by man, is: 33 per cent from petroleum and diesel, 27 per cent from coal and 5 per cent from nuclear fuels.

2.6.1 Coal

Coal is substantially more abundant than oil or gas, the total reservoir being 7×10^{12} metric tonnes, which is equivalent to 5×10^{22} calories. This is 1000 times more than the total global energy consumption from all fuels. The stock of coal is likely to last several centuries.

The natural defect of coal is that it is a dirty fuel to burn. On combustion, it emits sulphur dioxide which is an offensive gas, forms sulphuric acid in air and causes acid rain in far-away places. Thus, it poses environmental hazards (*see* acid rain in previous chapter). Excavation of coal from mines is followed by soil subsidence (depression) which endangers the residential areas above the coal mines. Moreover, flyash arising from combustion of coal is a nuisance as solid waste which brings about environmental problems. Also being a solid, coal is less convenient to handle than petroleum or natural gas.

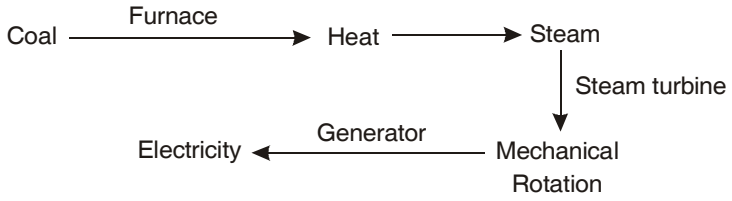
In order to overcome these problems, the developed countries use less polluting forms of coal by transforming it into gaseous, liquid or low sulphur, low-ash solid fuel. In a typical case, high-grade ash-free coal is produced as solvent-refined coal (SRC) by suspending pulverized coal in a solvent and treating with 2 per cent of its weight of hydrogen at a pressure of 1000 pounds per sq. inch and 450°C.

The product is a semi-solid, m.p. 170°C having a calorific value of 16,000 BTU per pound. This compares well with the best-grade anthracite coal.

2.6.2 Thermal Power

Electricity is generated by combustion of coal in a furnace. This heat is utilised to produce steam at high temperature and pressure. The latter is then used to run a steam turbine which is linked with the generator producing electricity.

Thermal power stations are operated on the above principle by combustion of coal in a furnace.



Thermal power contributes about 65,000 megawatts (MW) of electricity i.e., 70 per cent of India's power supply. Some of the major thermal power stations of the National Thermal Power Corporation (NTPC) of India are at Singrauli and Rihand in U.P., Talchar in Orissa, and Farakka in West Bengal. They are the sources of severe air pollution.

2.6.3 Methanol, CH_3OH

It is a convenient liquid fuel which can be produced from coal. On a commercial scale, it is produced by the reaction of carbon monoxide (CO) and hydrogen (H_2) at 50 atmosphere pressure and 250°C in the presence of copper-based catalyst. The reactants (CO and H_2) are obtained from coal, oxygen and steam:

$$CO + 2H_2 \longrightarrow \underset{\text{(methanol)}}{CH_3OH}$$

15 per cent methanol makes an excellent additive to gasoline which improves fuel economy and also cuts down the emission of practically all automobile pollutants.

2.6.4 Petroleum or Mineral Oil

The consumption of petroleum and natural gas is maximum in the developed countries and has become the status symbol of a country. USA is the largest consumer of petroleum in the world (about 80 per cent of total energy consumption in USA).

The Industrial Revolution (1780) was initially fuelled by coal but later on preference was given to oil and gas which provide cleaner fuels and easy transportation. The world reserve of petroleum is about 800 billion barrels (1 barrel = 31.5 gallons = 120 litres) which will last for less than 100 years.

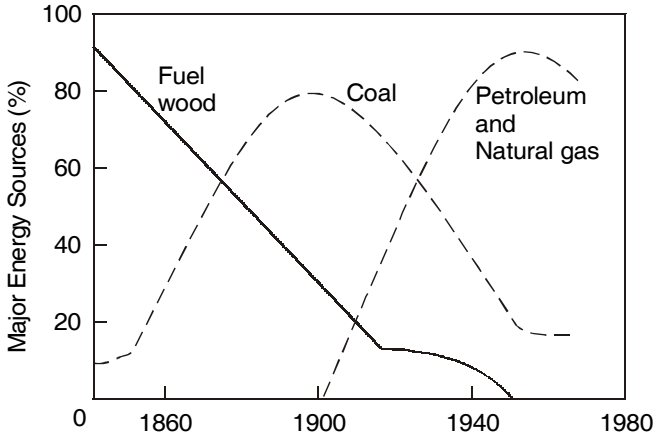


Fig. 2.9: *Energy consumption patterns in USA*

2.6.5 Hydroelectricity

The output from hydroelectricity (electricity from water) accounts for 21 per cent of total electricity generation, which is less than that from thermal power but greater than that from nuclear power. 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. In India, if water resources are properly utilised, it may be possible to generate more than 10,000 megawatts

of electricity. But at present, only 16 per cent or 6,500 megawatts 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 dam in a river for storage of water. Subsequently the stored water is released from upper level into a water-driven turbine placed at a lower level (Fig. 2.10) whereby electricity is generated. The hydel projects of Maithon, Panchyet and Jaldhaka are typical examples.

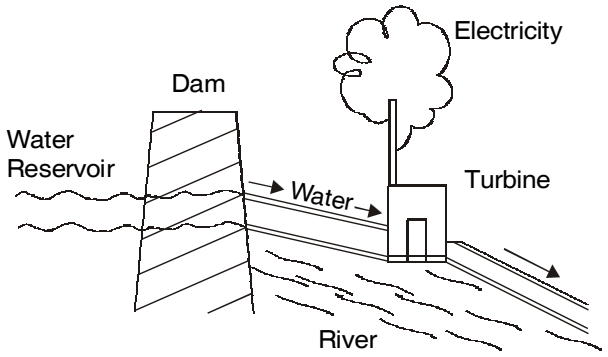


Fig. 2.10: *Hydroelectricity from hydel project*

The merits of hydroelectricity are: (1) clean source of energy; (2) no emission of greenhouse gases; (3) no consumption of fuel; (4) no need of high technology. But there are several environmental issues—flora and fauna in the region are disturbed due to construction of dam; local people become refugees as they are uprooted from their houses; the capacity of the reservoir gets reduced due to siltation; occurrence of floods in the area when surplus water has to be discharged in monsoon season. Hydroelectric dams are costly and take a long time for construction. In order to make hydroelectricity generation viable, it is necessary to adopt a long-term programme of afforestation, environmental

conservation, housing, public health and transport and ensure close co-ordination among these departments.

2.6.6 Nuclear Power

It contributes only 5 per cent of total electricity generation. Nuclear power plants do not emit polluting gases such as carbon dioxide, sulphur dioxide, like thermal power plants. But they have some severe drawbacks, viz. they are costly and release large quantities of radioactive fission products.

The radioactive wastes remain lethal (deadly) for thousands of years and for this no foolproof disposal method has been devised. That is why big nuclear power projects have not succeeded in the long run.

In India, the production target was fixed at 10,000 megawatts by 2000 AD, but the actual production is much less in the nuclear power stations at Tarapur, Rajasthan and Chennai. Nuclear power plants cannot match thermal power plants at present but in future, its unlimited resources will allow it to dominate the energy scenario when other energy resources are exhausted.

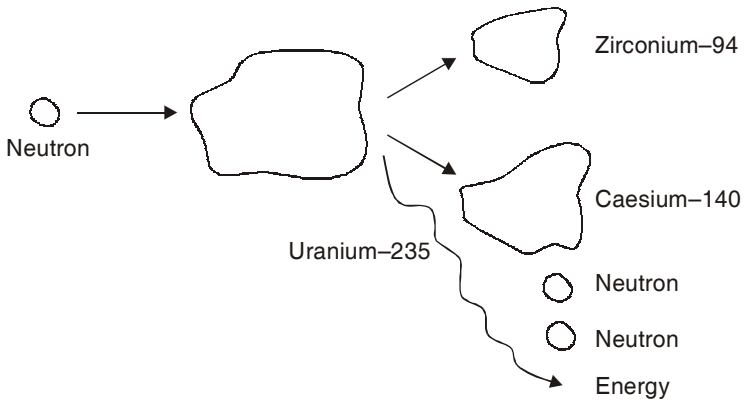


Fig. 2.11: *Nuclear fission*

At present, nuclear fission is used to produce nuclear power. Heavy large atoms like Uranium and Plutonium split up into smaller atoms when bombarded by neutrons (nuclear particles with mass 1 and charge 0). This splitting or fission liberates vast amounts of energy, which through conventional techniques is converted into electricity. Thus nuclear power is generated.

It has been calculated that 1 kg of Uranium-235 on a complete fission by slow neutrons releases energy equal to 1.7×10^{13} calories. This means energy-wise, 1 lb. of Uranium-235 ≡ 5 million lbs. of coal ≡ 20 million lbs. of T.N.T. (highly explosive chemical).

This is the secret of nuclear energy/power.

2.6.7 Wood

Wood is a major renewable natural resource. The major important products are wood, paper, cellophane, rayon, plywood, plastic, particle board, turpentine, methanol, etc. In USA, the production of wood and wood products is the fifth largest industry. Ideally, as in USA forests cover 38 per cent. of the total land area; in India it has come down to about 15 per cent at present from 80 per cent, 2000 years ago.

It is interesting to compare between India and USA in respect of deforestation. In USA, the Sunday issue of the leading newspaper, **New York Times** *consisting of 500 pages requires 25 hectares (1 hectare = 2.5 acres = 7.5 bighas) of forest.* According to an estimate, an American destroys as much forest for his needs for paper as an Indian for his domestic fuel. The value of a 50-year-old tree has been estimated as about more than Rs 20 lakhs—the various functions of a 50-year-old tree are roughly evaluated as follows:

(i)	Oxygen production (for 50 years)	Rs. 2,50,000
(ii)	Transformation into protein	Rs. 20,000
(iii)	Control of soil erosion and soil fertility	Rs. 2,50,000

(iv)	Recycling of water and control of humidity and atmospheric temperature	Rs. 2,50,000
(v)	Habitat for birds and other animals and insects, etc.	Rs. 2,50,000
(vi)	Control of air and heat pollution	Rs. 5,00,000
	Total	Rs. 15,20,000

This estimate excludes the value of timber/wood for furniture, fuels, medicines, etc. which will be an extra Rs. 3–4 lakhs.

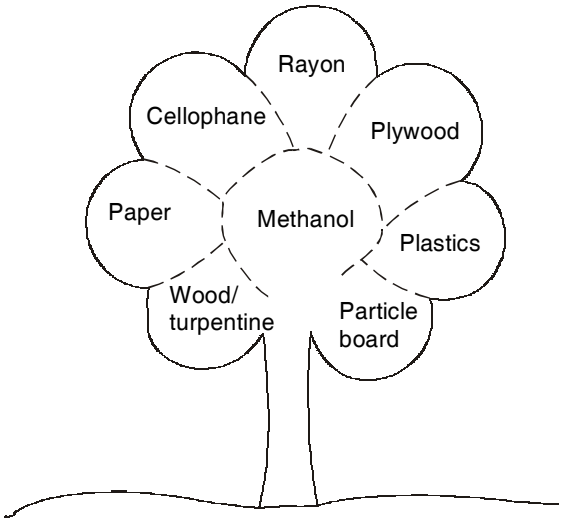


Fig. 2.12: *Trees—sources of many important products*

Thus the tree, with its 50-year services as above, costs about Rs. 20 lakhs (1980 estimate) which at present market prices will be around Rs. 40 lakhs. The public should be made aware of the value of a tree and its services to man and environment during its life time.

In India, 76 per cent of population lives in villages—almost all of them use wood as fuel for cooking. This is the main reason for extensive deforestation in rural areas: each

year we are losing about 1.3 million hectares forests. Deforestation helps increase in greenhouse gas, carbon dioxide concentration. Hence for the welfare of the country as a whole, it is essential to minimise deforestation by adopting alternative resources of afforestation on a large scale to meet the needs of domestic fuel.

2.6.8 Natural Gas

It is a better fossil fuel than coal and petroleum since on burning, it produces less carbon dioxide. For production of one unit of energy, mineral oil, coal and wood, on burning, produces respectively 35 per cent, 75 per cent and 80–90 per cent more carbon dioxide than natural gas. Hence, natural gas is the obvious choice as a cleaner fuel. Its reserves, however, are limited and can continue to feed only for the next 70–80 years. At present, in India the exploitable reserve of natural gas is about 700 billion cubic metres.

2.7 NON-CONVENTIONAL ENERGY RESOURCES

2.7.1 Solar Energy

India, being a tropical country, is blessed with abundant sunshine, 2,000 kilowatt hour/sq. metre (kWh/m^2) per year for about 200–300 days in a year. The daily sunshine is between 5–7 kWh/m^2. This is an enormous and model energy resource, which is clean, pollution-free and inexpensive. It requires to be converted into other forms of energy by suitable techniques—it can meet our energy demands forever. The solar energy, incident on earth in one week, is equivalent to the energy from the entire coal reserve of the world. Again the solar energy available on earth for 45 minutes is enough to meet our energy demand for one year.

However, the major problem is that sunlight is diffused (widespread) in nature and difficult to be stored and utilized. But with advanced technology, the present high costs may be cut down so that solar energy can be utilized on a large

scale in future. At present, solar energy is ten times more expensive than thermal power. But with advanced technology, it will be cheaper and will hold the key to meet our energy demands in future.

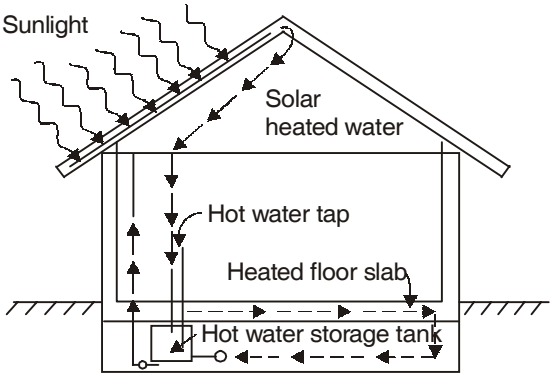
Sunlight may be directly converted into electricity through photovoltaic cell. The latter is a device for conversion of light energy into electrical energy. The efficiency of conversion of light into electricity is only 18 per cent and it is expensive at current prices. We can use solar energy in two ways: (1) use of solar heat and (2) use of solar electricity. Use of the former permits one to boil water or dry foodgrains. Accordingly, several gadgets have been produced such as solar cooker (for cooking), solar dryer (for drying grains), solar water heater (for heating water), solar distillation (for water purification), etc. Recently there have been extensive use of these solar equipments in rural and semi-urban areas. By using the second method, i.e., solar cell, sun rays are converted into electricity. Since these solar cells are made of silicon, these are called *silicon cells*.

The advantages of solar photovoltaics are that they can replace systems which use diesel and they are free from chemical and noise pollutions. They could be installed in remote areas in forests and deserts where installation of electric cables are cost-prohibitive.

Solar power, with government subsidy (Department of Non-conventional Energy Source (DNES), Government of India) is being used in remote rural areas in West Bengal in the forms of solar lanterns, solar streetlights and solar pumps (for irrigation). Solar powered small pumps are being used in Delhi, Haryana and Himachal Pradesh. It is desirable to use solar cookers in villages on a large scale so that extensive deforestation can be prevented. About 1 tonne of wood per head per year can be saved by this process.

Figure 4.5 illustrates a detailed design for a solar heated house during winter in developed countries like USA. In these countries, 20–25 per cent of fuel is consumed for providing hot water to houses and buildings. Sunlight is collected on

plates in the roof and the heat is transferred to a circulating water system. An average house with roof area about 1300 sq. ft. in central USA can get its energy supply for heating and hot water supply in December by this method. This may well apply to hill station houses in India in Jammu & Kashmir, Nainital, Mussoorie, Darjeeling, etc. in December–January.



Details of heating system

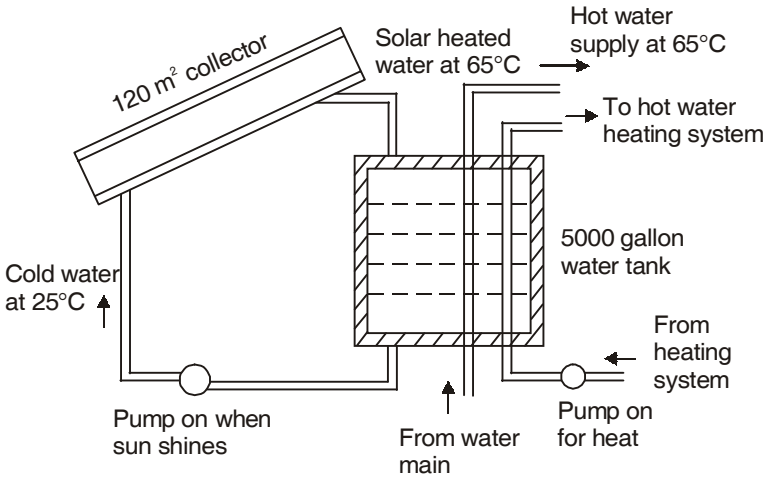


Fig. 2.13: *Solar heated house*

Figure 4.6 illustrates the function of a solar cell. Light is absorbed in a plate, with the generation of positive and negative charges, which are collected at the electrodes on either side. The silicon solar cell, developed for space programmes, consists of a sandwich of *n*-type and *p*-type silicon semi-conductors (e.g., silicon, germanium is a crystalline substance which is intermediate between a metallic conductor on the one hand and non-conducting insulator on the other)—the charge separation is developed across the junction between them. *p*-type silicon conducts positive charge while *n*-type silicon conducts negative charge. The silicon cell produces electricity but is quite expensive since very high-grade crystalline silicon is required for the cell.

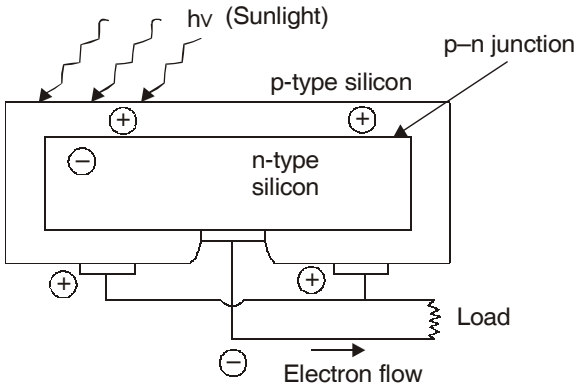


Fig. 2.14: *Solar cell for electricity generation*

2.7.2 Biogas

This offers an important solution to the present energy crisis in rural areas. Besides being an important domestic energy source, it offers an environmentally-clean technology. There is a vast reserve of biogas in Indian villages. 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 per cent collection efficiency, can yield 22,500 million cubic meters of biogas through biogas plants. This can replace kerosene oil whereby 14,000 million litres of kerosene per year

can be saved in villages. Besides, biogas slurries can produce 200 million tonnes of organic manure per year which can be a good substitute for chemical fertilisers for agriculture.

The composition of the biogas is: methane, carbon dioxide, hydrogen and nitrogen. The proportion of methane and carbon dioxide varies considerably as does the calorific value. At 40 per cent methane content, the calorific value is 3200 kcal/cubic metre, while at 50 per cent, it is 4500 kcal/cubic metre.

2.7.3 Wind Energy

This is a cheap and clean energy resource. India, with its climatic diversity, has areas which are quite windy. According to the Indian Meteorological Department, average annual wind velocity is 6.5 metres per second at a number of places in peninsular India as also along the coastlines of Gujarat, Western Ghats and parts of central India. Such velocities are available for 6–7 months in a year.

There are some limitations for setting up wind power mills or windmills. They require locations where the wind velocity is at least 6.5 metres per second. In Denmark and Holland, there are rows of windmills in extensive areas and these generate 50 megawatts of electricity. A standard windmill produces 55 kilowatts of electricity daily. Windmills spread over extensive areas on seashore or very high site present a beautiful scenery. Windmills prevent earthquakes where continuous wind flow causes soil erosion. In Scotland, Wales, Sweden, Germany and USA many windmills have been constructed for cheap generation of electricity.

The technology for harnessing wind energy has become commercial in some developed countries but in India it is still in the preliminary stage. The Department of Non-conventional Energy Sources, Government of India has installed several wind pumps with pumping capacity of 20 litres. A windmill with a capacity to pump 400 litres of water per hour at a pumping head of 19 metres has been installed. Prospective sites are in Gujarat and Orissa on the seacoast. A 100-km stretch of coastline in areas having wind speed of

10 km/hour from sea would lead to an installed capacity of 5000 megawatts. Wind energy can be used advantageously in remote rural areas and would help in saving fossil fuels.

2.7.4 Ocean and Tidal Energy

Ocean waves splash on ocean shores at tremendous speed—the mechanical energy in this process can be harnessed and converted into electrical energy. It has been found that in the middle of North Atlantic Ocean, each wave per 1-metre height can generate 90 kW electricity whereas on the oceanshore the waves can generate 25–70 kW. During storm, the generation level can rise up to 5 megawatts. Lots of researches are on in this area in U.K., Canada, Norway and Japan.

In a large chamber, the seawater is enclosed by oscillating water column method. Ocean/sea wave enters the chamber through an inlet pipe and forces the enclosed water upward at terrific speed—it will exert hydraulic pressure on enclosed air which in turn can rotate a turbine. Such method is expensive at present but it has immense potential which can be exploited in future with advanced technology.

Tidal Wave

Tidal wave can also be tapped for generating electricity. During flow tide seawater enters river—it is possible to store such seawater in a big tank and rotate turbines by the mechanical force in the process and generate electricity. It is necessary that about 3–5 metres high seawater through flow tide enters the chamber. USSR (now CIS) and China have built small tidal power plants. In India, the probable sites for exploration of tidal energy are the Gulf of Kutchch and Cambay and Sunderbans and also near Andaman, Nicobar and Lakshadeep islands. The sites should be within 20–30 km from the shore in order to facilitate power transmission to the islands.

2.7.5 Geothermal Energy

The earth's core has a vast source of thermal energy, which has been tapped in many developed countries.

In France and Hungary, hot water from hot springs has been utilised for heating houses and agricultural farms. Italy is the pioneer in this field. Later on USA, Philippines, Japan and New Zealand have been working on the exploration of geothermal energy as an energy resource.

During the oil crisis period in 1973, England developed the technology for harnessing geothermal energy. If in many areas wells are dug about 5-km. deep, then geothermal energy may be exploited. With advanced technology, it may be possible to generate electricity from geothermal energy in India and other developed countries.

2.7.6 Energy Plantation

Energy Production from Wastes

Energy can be produced from wastes—agricultural, industrial and municipal wastes.

Agricultural wastes are mainly crop residues. They are dried and used as fuel. Straw, jute sticks and other crop residues are burnt by villagers for cooking and partial boiling of paddy.

In certain industries, the waste materials can be utilised as a source of energy. Food processing, jute, sugar, paper and textile industries are the major industries where the waste materials can be utilised for the production of heat and electricity. Various processes have been developed for effective use of bagasse, jute, cotton and paper industries for energy production.

Petro-crops: Some latex-containing plants like *Euphorbias* and oil palms are rich in hydrocarbons and can yield an oil-like substance under high temperature and pressure. This oily material can be burnt in diesel engines directly or may be refined to form gasoline.

2.7.7 Hydrogen Fuel

An attractive energy storage scheme is chemical storage in the form of H_2. This gas is generated directly by electrolysis of water (H_2O), as shown in Fig. 2.15. Electricity is passed between electrodes immersed in a conducting aqueous solution. H_2 is generated at the cathode and O_2 at the anode.

The energy stored in H_2 can then be reconverted into electricity using the reverse of the electrolytic cell called the *fuel cell*, as shown in Fig. 2.15. Here H_2 is oxidised at the cathodes, where electrons are produced, and passed through the circuit to the anode, where O_2 is reduced. The overall efficiency of this conversion and reconversion is quite lower to various energy barriers connected with the electrode processes. A lot of current electrochemical researches are centered on lowering these energy barriers.

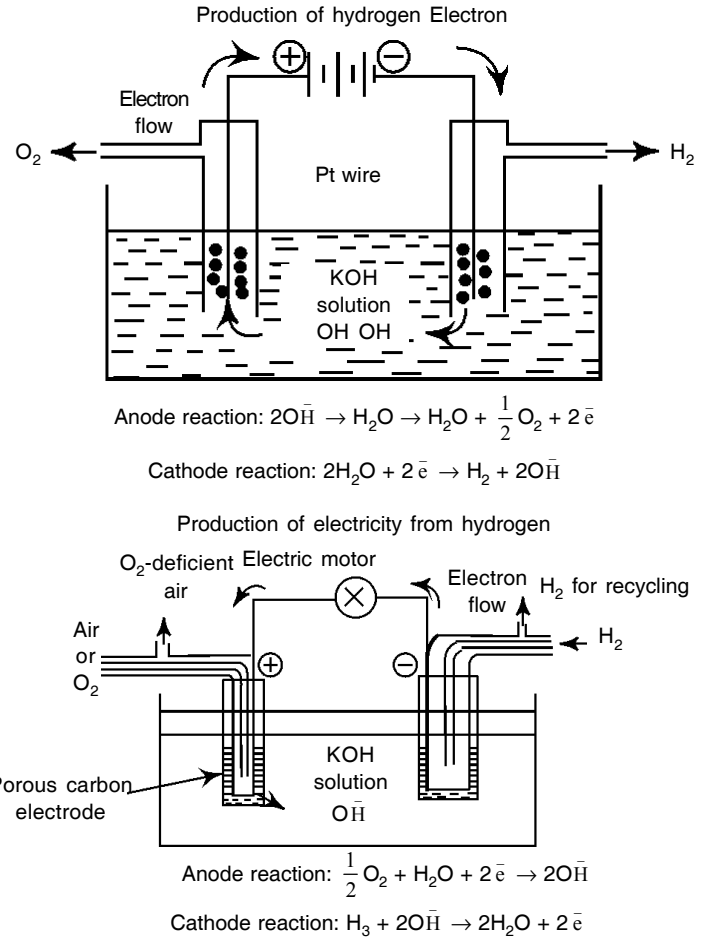


Fig. 2.15: *Storage and production of electricity with hydrogen*

The problem of energy transport would be solved to a large extent by the ability to store energy in the form of H_2. H_2 transport by pipeline is more efficient and less expensive than electrical transmission over large urban centres. These considerations have given rise to the concept of the hydrogen economy (Fig. 2.16 in which H_2 will be the main energy currency). It can be consumed directly for electrical generation and heating, and can be used to synthesize liquid fuels by chemistry similar to that described for coal gasification.

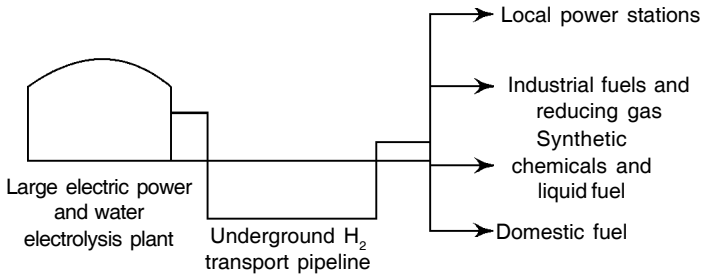


Fig. 2.16: *The Hydrogen economy*

2.7.8 Gasohol

Gasohol blended with up to 20% methanol or ethanol is known as gasohol. This can be used as a fuel in existing internal combustion engine, with little or no adjustment. Individually, methanol or ethanol itself can be used as fuel (instead of gasoline) in a suitable designed internally combustion engine. Methanol is produced by the destructive distillation of wood, or from synthesised gas manufactured from coal or natural gas (Sec. 2.6.3).

Because of its photosynthetic origin, alcohol is a renewable resource.

The manufacture of alcohol can be carried out by fermentation of sugar resulting from the hydrolysis of cellulose in wood wastes and crop wastes. Fermentation of these waste products provides an excellent opportunity for recycling.

Brazil is the leading country in the manufacture of ethanol for fuel. This country possesses few fossil-fuel resources, but it provides optimum conditions for the growth of large quantities of biomass from the fermentation of sugarcane. In Brazil, a new abundant source of fermentable biomass is *Cassava* or *manioc*, a root crop growing in large quantities throughout the country.

Questions

1. Name the major natural resources.
2. Give examples of (a) renewable and (b) non-renewable resources.
3. What is the significance of forest resources?
4. Explain the imortance of biodiversity and its conservation.
5. What are the sources of water? Name also the sources of freshwater. Express their quantities in term of percentage of water resources.
6. Name the important water quality perameters. Mention their tolerance limits as per USPH standards.
7. What are water-borne diseases?
8. Give an account of environmental factors for the outbreak of cholera. How can it be prevented?
9. Write a note on fluorosis.
10. What are the major minerals mined to the maximum extent?
11. How do you classify metals? Name some base metals and also precious metals.
12. Write notes on:
    (a) Nitrogen cycle
    (b) Carbon cycle
    (c) Phosphate cycle
    (d) Sulphur cycle
    (e) Hydrologic cycle

13. Name conventional and non-conventional sources of energy. Compare their effects on environment.
14. What are the products of combustion of coal? Discuss their damaging effect on environment.
15. Starting from coal, how would you manufacture material?
16. Write notes on:
    (a) Biogas
    (b) Hydroelectricity
    (c) Geothermal energy
    (d) Hydrogen fuel
17. "Solar energy is the energy for future in India." Elucidate.
18. Comment on: "Wood is a major renewable energy resource — it offers multiple benefits to man, but it is vanishing fast."

Unit-III

A. Environmental Pollution

Man-made activities have caused environmental degradation. We have degraded lands, destroyed forests at suicidal rates, thrown tonnes of toxic waste into rivers indiscriminately and poured toxic chemicals into the seas. Furthermore, we discharged green-house gases into the atmosphere leading to climatic changes. The net result is: we are surrounded by pollution in our daily lives—we breathe, we drink, we eat pollution.

We shall discuss water pollution, land pollution, noise pollution and air pollution in this and the next chapters.

3.1 *WATER POLLUTION*

The normal uses of water for public supply are—recreation (swimming, boating, etc.), fish, other aquatic life, and wildlife, agriculture (irrigation), industry, navigation, etc. Any change in the dynamic equilibrium in aquatic ecosystem (waterbody/biosphere/atmosphere) disturbs the normal function and properties of pure water and gives rise to the phenomenon of water pollution. The symptoms of water pollution of any water body/groundwater are:

- Bad taste of drinking water
- Offensive smells from lakes, rivers and ocean beaches
- Unchecked growth of aquatic weeds in waterbodies (eutrophication)

- Dead fish floating on water surface in river, lake, etc.
- Oil and grease floating on water surface

The quality of water is of vital concern for mankind since it is directly linked with human welfare. It is a historical fact that faecal (human excreta or stool) pollution of drinking water caused water-borne diseases, which wiped out entire populations of cities. In the developing countries like India, everyday some 25,000 people die of water-borne diseases, e.g., jaundice, hepatitis, cholera, dysentery, etc. In India about 2 lakhs out of 6 lakh villages have no access to safe drinking water—women have to walk 1–14 km daily for collecting water for drinking and cooking. In urban areas, 40 per cent people are without access to safe water. The major sources of water pollution are domestic sewage from urban and rural areas, agricultural run-off (wash water) and industrial waste which are directly or indirectly discharged into waterbodies.

3.1.1 Water Pollutants

The large number of water pollutants are broadly classified under the categories:

1. Organic pollutants
2. Inorganic pollutants
3. Sediments
4. Radioactive materials
5. Thermal pollutants

Organic Pollutants

These include domestic sewage, pesticides, synthetic organic compounds, plant nutrients (from agricultural run-off), oil, wastes from food-processing plants, paper mills and tanneries, etc. These reduce dissolved oxygen (D.O.) in water. Dissolved oxygen (D.O.) is essential for aquatic life, the optimum level being 4–6 ppm (parts per million). Decrease in D.O. value is an indicator of water pollution. The organic

pollutants consume D.O. through the action of bacteria present in water.

Sewage and agricultural run-off provide plant nutrients in water giving rise to the biological process known as *eutrophication*. Large input of fertiliser and nutrients from these sources leads to enormous growth of aquatic weeds which gradually cover the entire waterbody (*algal bloom*). This disturbs the normal uses of water as the waterbody loses its D.O. and ends up in a deep pool of water where fish cannot survive.

The production of synthetic organic chemicals (more than 60 million tonnes each year since 1980) multiplied more than 10 times since 1950. These include fuels, plastic fibres, solvents, detergents, paints, food additive, pharmaceuticals, etc. Their presence in water gives objectionable and offensive tastes, odour and colours to fish and aquatic plants.

Oil pollution of the seas has increased over the years, due to increased traffic of oil tankers in the seas causing oil spill and also due to oil losses during off-shore drilling. Oil pollution reduces light transmission through surface water and hence reduces photosynthesis by marine plants, decreases D.O. in water causing damage to marine life (plants, fish, etc.) and also contaminates sea food which enters the human food chain.

Pesticides have been largely used for killing pests and insects harmful for crops and thereby boosting the crop production. At present, there are more than 10,000 different pesticides in use. They include insecticides (for killing insects), e.g., DDT (dichloro diphenyl trichloroethane), herbicides (for killing weeds and undesirable vegetation) and fungicides (for killing fungi and checking plant disease).

It has been found that pesticide residues contaminate crops and then enter the food chain of birds, mammals and human beings. The persistent pesticide, viz., DDT (which is

not degraded in the environment) accumulates in food chain, getting magnified in each step from seaweed to fish and then to man by about ten thousand times (10^4). Thus, the average level of DDT in human tissues is found to be 5–10 ppm, maximum being among the Indians (25 ppm) compared to the Americans (8 ppm).

Inorganic Pollutants

This group consists of inorganic salts, mineral acids, metals, trace elements, detergents, etc.

Acid mine drainage: Coal mines, particularly those which have been abandoned, discharge acid (sulphuric acid) and also ferric hydroxide into local streams through seepage. The acid on entering the waterbody destroys its aquatic life (plants, fish, etc.).

Sediments

Soil erosion, as a matter of natural process, generates sediments in water. Solid loadings in natural water are about 700 times as large as the solid loading from sewage discharge. Soil erosion is enhanced 5–10 times due to agricultural and 100 times due to construction activities. Bottom sediments in aquatic bodies (streams, lakes, estuaries, oceans) are important reservoirs of inorganic and organic matter, particularly trace metals, e.g., chromium, copper, nickel, manganese and molybdenum.

Radioactive Materials

Radioactive pollution is caused by mining and processing of radioactive ores to produce radioactive substances, use of radioactive materials in nuclear power plants, use of radioactive isotopes in medical, industrial and research institutes and nuclear tests. The discharge of radioactive wastes into water and sewer systems is likely to create problems in future.

Thermal Pollutants

Coal-fired or nuclear fuel-fired thermal power plants are sources of *thermal pollution*. The hot water from these plants is dumped as waste into nearby lake or river where its temperature rises by about 10°C. This has a harmful effect on the aquatic life in the waterbody whose D.O. is reduced and as a result, fish kill is quite common.

3.1.2 Groundwater Pollution/Arsenic Contamination

Groundwater is relatively free from surface contamination as it is located more than about 50 ft below the land surface and the surface water gets filtered or screened by the underlying layers of soil, sand and stone pieces. But even then it gets contaminated due to leaching of minerals below the earth's surface.

An important case is that of *Arsenic (As) contamination of groundwater*. This arises from excessive pumping of groundwater by shallow tube wells for irrigation in some West Bengal districts along the Hooghly river course and also in Bangladesh along the Padma river course. In this process, air (oxygen) is injected into groundwater bed which leaches the overlying mineral, iron pyrites (iron, arsenic, sulphide), oxidises it and releases arsenic into groundwater.

More than one million people in six districts of West Bengal drink arsenic-contaminated groundwater from tube wells in the region. Among them, 20 lakh people suffer from various diseases related to arsenic poisoning like loss of hair, brittle nails, bronchitis, gangrene, etc. Several hundred deaths have also been reported. Similar calamity has threatened the lives of Bangladesh in the districts along the Padma river course.

3.1.3 Case Study of Ganga Pollution

The most typical example of river pollution is the *Ganga Pollution*.

The Ganga originates from the Himalayan glacier and flows along a stretch of some 2525 km before joining the Bay of Bengal. The Ganga basin is fertile and home of about 40 per cent of population (400 million people) of the country. The river has been hailed as the "Holy Ganga" and regarded as the lifeline of the country. But in recent years it is ranked as the most-polluted river of India and a *killer* in the highly-polluted areas.

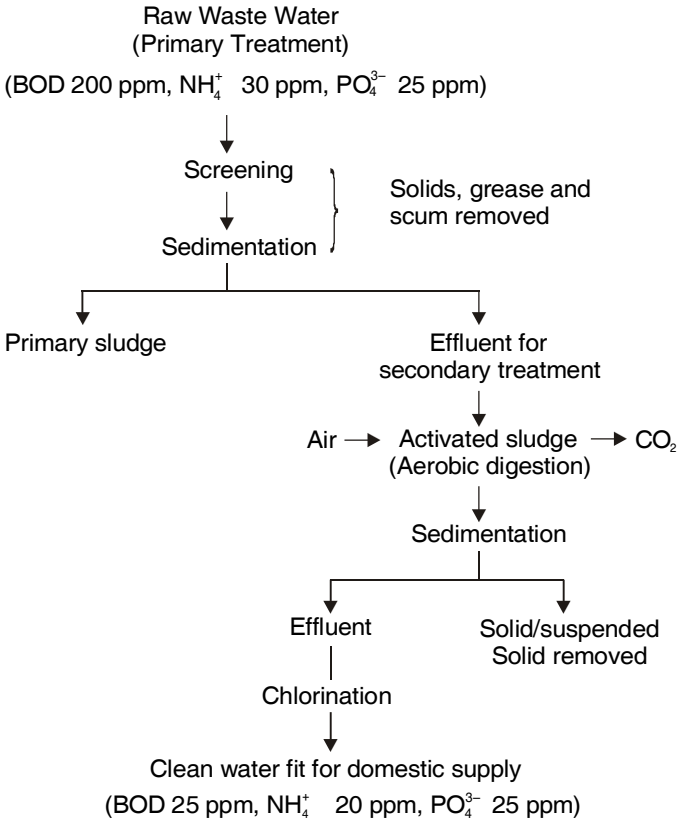
The Ganga basin carries water from 25 per cent of land. It is responsible for agricultural prosperity of UP, MP, Haryana, Rajasthan, Himachal Pradesh, Bihar and West Bengal. Ganga is the source of drinking water in the region and irrigation water for agriculture—she also supplies fish to the local markets and water to industries on both sides of the river. The Ganga basin provides maximum population density—many class I (population 100,000 and above), class II (pop. between 50,000 and 100,000) and class III (pop. 20,000 to less than 50,000) cities have grown in this region. Both domestic and industrial sewages join the Ganga river without any treatment and thus causes terrible pollution.

Hooghly river (in West Bengal) near Kolkata presents the worst polluted zone. There are more than 150 industries on both sides of the 125 km stretch river belt—there are about 270 outlets of untreated sewage to the river Hooghly. The entire 140 sq. km metropolitan area covering both banks of the Hooghly river is exposed to ecological disaster. Besides huge quantities of soil from soil erosion due to extensive deforestation are washed by rain water into the river causing siltation. This reduces the flow of water in the Bhagirathi-Hooghly river with the result that ultimately the river will be choked and dead. In 1919, the flow of water in the Ganga was 1,10,000 cusecs (1 cusec = 1 cubic foot of water flowing per second) whereas in 1971 it was 40,000 cusecs only which during summer drops to 20,000 cusecs. This should be

enough to sound the alarm bell to the Government—Kolkata and Haldia ports can survive only on 40,000 cusecs of water.

3.2 WASTE WATER TREATMENT

Water pollution is caused by domestic sewage (84 per cent) and industrial sewage (16 per cent). Though the latter has less load on waterbody, it contains toxic matter (inorganic and organic) which are more hazardous.



BOD = Biological Oxygen Demand (Index for organic matter content)

1 ppm = 1 part per million, i.e. 1 in 10^6 parts

Fig. 3.1: *Municipal waste water treatment (primary and secondary)*

3.2.1 Domestic Waste Water Treatment

Sewage treatment plants, in general, depend on biological decomposition of non-toxic organic wastes using bacteria. Such biological decomposition is carried out under aerobic conditions, i.e., in the presence of plenty of oxygen.

$$\text{Organic wastes (carbon, oxygen, hydrogen, sulphur, fluorine)} + O_2 \text{ (oxygen)} \xrightarrow{\text{bacteria}} CO_2 \text{ (carbon dioxide)} + H_2O \text{ (water)} + NO_3^- \text{ (nitrate)} + NH_4^+ \text{ (ammonium ion)}$$

The process, commonly used for municipal waste water, is shown in Fig. 3.1. In the first stage, solid wastes are removed from water by screening—any scum (suspended matter) is removed and the sludge (muddy solid or sediment) allowed to settle at the bottom. The residual liquid is exposed to biological oxidation of soluble organic materials through a bed of microbes in activated sludge. Then the solids are removed after sedimentation. Finally the liquid effluent is subjected to chlorination for destroying pathogenic micro-organisms. Now this effluent is fairly clean and suitable for domestic use.

3.2.2 Drinking Water Supply

Treatment of drinking water supply is a matter of public health concern. The water treatment plants, in general, are simpler than sewage treatment plants. They operate in three steps—

(i) Aeration to settle suspended matter.

(ii) Coagulation of small particles and suspended matter by lime and ferric chloride.

(iii) Disinfection by chlorination to kill viruses, bacteria, etc. The purified water is then supplied by municipalities through pipes for domestic uses.

3.3 LAND POLLUTION

Land or soil is polluted by indiscriminate discharge of waste—domestic, commercial, municipal and industrial. Liquid waste is partly absorbed by soil, partly seeps into underground water and the rest joins waterbodies in the locality. It is solid waste which, when dumped into land, accumulates on it and causes pollution.

3.4 NOISE POLLUTION

Noise is part of our environment. With progress in industrialisation, the noise level has been rising continuously. In the 19th century the development of the steam engines, petrol engines and machines in factories resulted in increasingly noisy environment. In the 20th century this was further accelerated by introduction of diesel engine, jet engines, turboprop, high-tech machineries, construction site machineries and automobile traffic. Noise has been recognised as one of the dimensions of pollution which brings about degradation of the environment and creates health and communication hazards.

3.4.1 Sound and Human Acoustics

Sound consists of wave motion in an elastic medium such as air, water or solids (e.g., metals, plastics, wood, bricks, etc.). Sound waves travel through the medium from the source to the recipient or listener. The rate of the oscillation of the medium is known as the *frequency* of the sound, the unit being *hertz* (*Hz*) or *cycles per second*. The frequency is a measure of the pitch of the sound received by the listener. High frequencies mean high-pitched sounds which are more irritating to the individual than low frequencies. The second parameter of sound is *sound pressure* which is measured in newtons per sq. metre (N/m^2). The third parameter on sound is its *intensity*, expressed in watts per sq. metre, i.e., the quantum of sound energy that flows through unit area of the medium in unit time.

The human ear receives sound waves which set up oscillations in the ear drum (tympanic membrane). These oscillations cause movement of three small bones in the middle ear behind the ear drum. These then pass through the fluid in the inner ear to the auditory nerve and finally transmitted to the brain. The oscillations or sound are intensified and interpreted in the brain, which can select sounds into different categories—speech, music, noises, etc.

The sensitivity of the ear varies from person to person. With ageing, people lose hearing power gradually. A young person, 18-year-old, with normal hearing, has audio range between 20 Hz and 20,000 Hz. The audio sense is sharpest in the frequency range 2000–8500 Hz.

3.4.2 Noise Measurement Units

As mentioned before, sound pressure and sound intensity are the two important parameters of noise. The common scientific acoustic unit is the **Decibel** (**dB**)[1]. It is not an absolute physical unit like volt, metre, etc. but is a ratio, expressed in logarithmic scale relative to a reference sound pressure level.

The reference intensity used is the threshold of hearing which means sound which can be first heard at a sound pressure of 2×10^{-5} newtons per sq. metre or sound intensity of 10^{-12} watts per sq. metre.

Noise meters have been designed for noise measurement from low to high frequencies, characteristic of human ear capacity. These meters record the dB scale for routine measurement of general noise levels. Refined noise meters have been developed to take care of peak noise levels, duration of noise exposure and quality of noise which are aspects of specified noise situation.

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[1] *Decibel (dB) = log intensity measured/reference intensity.*

Table 3.1: *Sound measurement (intensities, pressures and decibels) in air at room temperature and sea level pressure*

Intensity (Wm^{2-})	*Pressure* (Nm^{2-})	*dB*	*Sound source*
100	2,00,000	200	Saturn rocket take off
1.0	20	120	Boiler shop
10^{-2}	2.0	100	Siren at 5 metres
10^{-4}	0.2	80	Heavy machinery
10^{-6}	0.02	60	Normal conversation at 1 metre
10^{-8}	0.002	40	Public library
10^{-12}	2×10^{-8}	0	Threshold of hearing

3.4.3 L_{10} (18 hours) Index

This is used for road traffic measurement, adopted in UK for noise legislation. The index is expressed in dB—it is the arithmetic average hourly values of the noise level exceeded for 10 per cent of the time over 18 hours between 6:00 and 24:00 hours on any normal weekday. It includes peak noise values and fluctuation of noise depending on the type of vehicle and traffic density.

3.4.4 Effective Perceived Noise Level (L epn)

This is recommended for aircraft by the International Civil Aviation Organisation (ICAO) as the standard for use in noise evaluation. The index is based on the scale equivalent to the dB scale + 13 and takes care of the peak frequency of jet aircraft noise as well as duration of aircraft flyover.

3.4.5 Noise Classification

There are broadly three categories of noise:

(i) Transport noise
(ii) Occupational noise
(iii) Neighbourhood noise.

Transport Noise

Transport noise can be further sub-divided into (i) Road traffic noise, (ii) Aircraft noise and (iii) Rail traffic noise.

Road Traffic Noise: Traffic noise is increasing over the years with increase in the number of road vehicles. Traffic speed is the major cause of noise. The noise volume is enhanced with increase in traffic speed. Modern highways and traffic system encourage higher speeds.

In general, on urban roads there are distinct traffic peaks in the morning and evening (10 a.m. and 6 p.m.) as people travel to and fro workplaces. Heavy diesel-engined trucks are the noisiest vehicles on roads at present. The permissible noise levels for cities prescribed by the Central Pollution Control Board of India are shown in Table 3.2.

These limits are, however, violated in all big cities in India, Calcutta being the worst case. The average noise levels in busy streets in Calcutta during rush hours (between 10:30-12:00 hrs and 18:00-19:30 hrs.) are 90 dB. People live in an environment of noise generated by blasting horns, rumbling tyres and screeching brakes. Awful road accidents contribute to the misery.

Table 3.2: *Permissible noise levels (cities)*

Areas	*Day*	*Night*
Industrial	75 dB	65 dB
Commercial	65 dB	55 dB
Residential	50 dB	45 dB
Sensitive areas up to 100 m around hospitals, schools	50 dB	40 dB

Aircraft Noise: The noise levels have peak values when aircraft fly low and overhead or take off and land at airports. The noise limits prescribed by UK airports for take-offs are 110 PNdB (1 PNdB = dB scale + 13) during day and 102 PNdB during night. These may be compared with the values in USA: 112 PNdB during day at New York.

Rail Traffic: It is less of a nuisance as compared to the previous types of traffic noise.

Occupational Noise : Industrial workers are exposed to noisy working environment for 48 hours a week (8 hrs. a day for 6 days a week). Some typical occupational noise levels are given in Table 3.3.

Millions of workers suffer from progressive hearing damage and become prone to accidents under their working conditions. Their working efficiency is also affected.

Neighbourhood Noise: Loud TV and radio sets, loud cassettes, loudspeakers in public functions, disco music, etc. are sources of neighbourhood noise, which disturb and irritate the general public and also harm the patients.

Table 3.3: *Occupational noise levels*

Industrial source	*Noise level (dB)*
Steel-plate riveting	130
Oxygen torch	126
Boilers' shop	120
Textile loom	112
Circular saw	110
Farm tractor	103
Newspaper press	101
Bench lathe	95
High-speed drill	85
Supermarket	60

3.4.6 Noise Pollution Hazards

The human ear drum is struck by noise in the form of air-borne mechanical energy. While the tolerable conversation level is 65 dB at a distance of 1 metre, 125 dB gives the sensation of pain in the ear and 150 dB might be a killer.

High-intensity noise for continuous periods is the major cause for ear damage. If a noise level exceeding 90 dB in the

mid-frequency range reaches the ear for more than a few minutes, then the sensitivity of the ear will be reduced.

Noise pollution can cause pathological or psychological disorders. High frequencies or ultrasonic sound above the audible range can affect the semi-circular canals of the inner ear and make one suffer from nausea and dizziness. Mid-audible frequencies can lead to resonance in the skull and thereby affect the brain and nervous system. Moderate vibration can also cause pain, numbness and cyanosis (blue colouration) of fingers while severe vibration results damage to bones and joints in the hands with swelling and stiffness.

In industrial and other establishments the general impact of noise pollution is lower efficiency, reduced work rate and higher potential for accidents and injuries.

In residential areas, even low-frequency noise of 50–60 dB at night disturbs sleep, particularly among the aged people, causing adverse effect on health.

Children, exposed to excessive noise, show signs of behavioural disorder which in later age develop into destructive nature and neurotic disorders in the adult.

Excessive noise is one of the major factors for chronic exhaustion and tension in our daily lives. This may explain why more and more people tend to become addicted to alcohol, tobacco and drugs.

Noise pollution has also impact on travel of migratory birds from winter to tropical climate. Thus, the increase of noise pollution in Kolkata and construction of high-rise buildings near Alipur Zoological Garden have led to decline in the number of migratory birds from CIS (former USSR) from 15,000 in 1980 to 2000 in 1990.

3.4.7 Permissible Noise Levels

In this age, many people work and live in environment where the noise level is not hazardous. But over the years they suffer from progressive hearing loss and psychological

hazards. The maximum permissible noise levels are summarized in Table 3.4.

Table 3.4: *Maximum permissible noise levels*

Situation	*Permissible noise, dB*
Road traffic near residential areas	70
Ear protection required	85
Factory work (48 hr. week)	105
Prolonged noise causing permanent damage	100
Threshold of pain (30 sec. duration)	120
Maximum for sonic boom	150
Ear-drum rupture	180
Lungs damage	195

3.4.8 Control of Noise Pollution

Noise pollution is closely related to increase in industrialisation and urbanisation. It cannot be entirely eliminated but it can be kept at a safe level through adoption of some measures:

(a) Control of noise intensity at the source itself.

(b) Noise absorption measures placed between the noise source and the recipient.

(c) Use of protective measures by the recipient so that the ear drum is saved.

The common noise generation sources are: generators (for power supply), water pumps, loud speakers, cassette playing shops, blowing of air horns in motor vehicles, landing and take off by aeroplanes, noise of machines in factories, etc. The specific laws in this respect should be strictly enforced. This must be backed by public awareness and vigilance.

3.4.9 Solid Waste Disposal

The methods of waste disposal depend on the nature of waste. Most solid wastes are dumped on land as soil heaps or as landfill to quarries or mine shafts or as dumps consisting of a wide range of materials. Besides these, some wastes are dumped into the seas. The various modes of waste disposal are illustrated in Fig. 3.2.

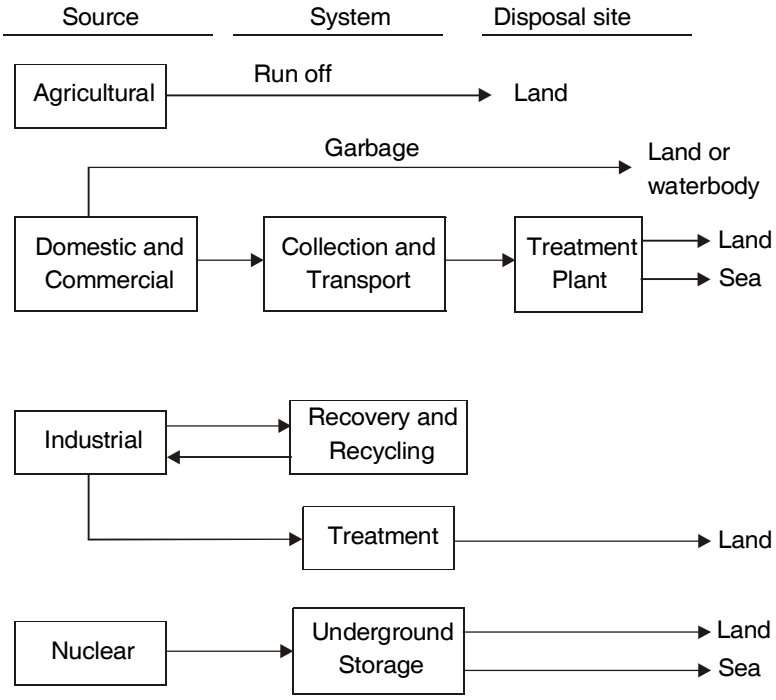


Fig. 3.2: *Modes of waste disposal*

3.4.10 Detoxification of Toxic Wastes

The toxic wastes are converted into less hazardous products by treatment with acids; cyanide-containing wastes are decomposed by interaction with oxygen to form carbon dioxide and nitrogen. The decomposition can also be carried out biologically by means of suitable micro-organisms

(bacteria). Sludge from petroleum refineries may be spread on the soil and left to decay into harmless products.

Incineration of toxic wastes is another method for their disposal. However, incinerators need pollution control devices and careful monitoring to make sure that they do not release toxic byproducts into the environment.

3.4.11 Land and Ocean Disposal

Radioactive wastes from nuclear power stations are generally fused in glass containers and lowered to the ocean floor. In USA, such wastes are sealed in metal drums and buried underground at great depths. But they may leak or be damaged by earthquake and release the wastes into groundwater.

Hazardous wastes dumped into soil/ditch have chances of leaking to the ground. A typical case history is that of the *Love Canal* in Niagara Falls, New York, USA. In 1930–53 the canal ditch was the dumpsite for hazardous chemical wastes and municipal wastes. In 1953, the ditch was filled up; it was covered with clay and sold to the City Board of Education, which built an elementary school. Some houses were also built. Soon the residents of these houses (300 families) and the school authorities complained of foul odour and illnesses. In 1978, it was found that some 25 toxic organic compounds, known as *carcinogens*, leaked into the basements in the area and dispersed into air. As a result of these findings, the State of New York declared emergency in the area and transferred all the families and the school from the site (Fig. 3.3: p. 82).

3.4.12 Non-hazardous Waste Management

Two techniques are available—

(i) Landfill

(ii) Incineration

Sanitary Landfill

Miscellaneous refuse materials are those from household, hotels, stores, markets, restaurants, etc. (e.g., food wastes, vegetable and animal wastes, paper, cardboard, wood, boxes, rubber, leather, plastics, tin cans, crockery glass, metals, etc.), ashes (from fires used for cooking, heating buildings, etc.), dead animals, industries and agricultural fields, etc. In the developed countries, e.g., USA, it is a common practice for each household to burn the bulk of waste in a backyard incinerator. Mainly food scraps, bottles and combustible articles are contained in packets for collection by municipality. The percentage of paper, rubber, leather, plastics, metals and glass increases considerably with increasing industrialisation in developed countries compared to developing countries because of wide application of these materials in their daily lives.

Most of the solid waste is dumped on land in heaps in uncontrolled manner in developing countries. Some waste is used for landfilling in abandoned quarries or mines. The developed countries prefer the second method, viz. incineration (*see* next section). Industrial wastes are treated in treatment plants and valuable materials recycled. In other cases, the volume of the waste is reduced by pulverisation (33 per cent) or by incineration.

For sanitary landfill, the following principles should be followed:

(i) Solid wastes should be deposited in a regulated manner, preferably in gravel pit.

(ii) Solid wastes should be spread in thin layers with ground cover of at least 15 cm.

(iii) All factors likely to contribute to water pollution should be eliminated.

(iv) The wastes should not be burnt openly.

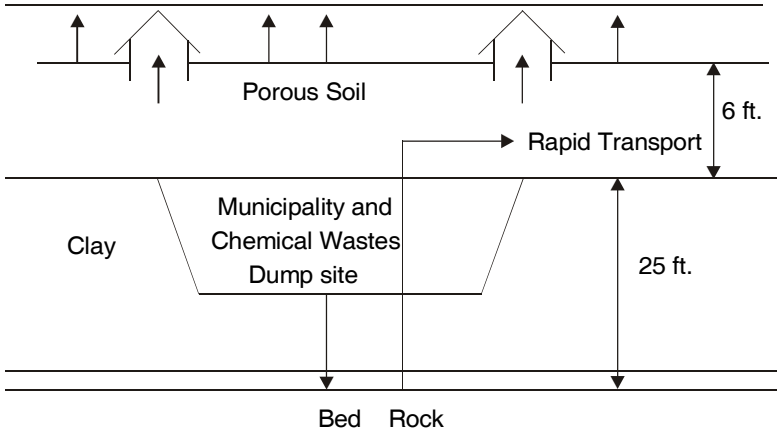


Fig. 3.3: *Transport of toxic organic chemicals from Love Canal dumpsite into adjoining areas*

In the man-made gravel pit, fine-grained soil is useful in containing undesirable gas and water movements outside the landfill area. With increase in urbanisation and expansion of cities beyond the periphery, land suitable for landfill becomes more and more scarce. In such cases, planned sanitary landfill, backed by modern solid waste management, can provide the community with better environmental management.

Composting and Municipal Waste Composting Projects

This is a biological process where fresh organic wastes are allowed to be decomposed into humus-like substances. The process is conducted by a complete automatic system which consists of several steps:

(1) The crude refuse is dumped into a container or to a belt conveyor. (2) Iron or metallic particles are removed by a magnetic separator. (3) The material is then transferred in a wet condition to a rotatory cylinder, analogous to a rotatory drier.

The cylinder rotates slowly on large tyres and the wastes move from one end to the other. They are thoroughly mixed and pulverised by abrasion. Air is introduced at low pressure

throughout the length of the cylinder. Here aerobic micro-organisms ensure rapid decomposition of the wastes under aerobic conditions.

3.5 POLLUTION AND PUBLIC HEALTH ISSUES

Very few people have paid any attention to the dark side of industrialisation, particularly to the growing dangers it poses to the health of people. Hardly a day passes when hundreds do not succumb to the accidents or diseases caused by growing pollution of the environment in general and the increasing occupational hazards or die in major industrial disaster as in Bhopal.

Industrialisation is creating a high-risk environment for all. But it is the poor labourers/workers who suffer the most. They get the dirtiest and most hazardous job and are compelled to live in the dirtiest environment in close proximity to the industries. The society benefits from the industries but at the cost of the lives of the poor workers who are most neglected.

3.5.1 Hazardous Products

During the last 50 years, about 6-million chemicals have been synthesised at the rate of 10,000 new ones every month. Some 60,000–70,000 chemicals are used extensively in millions of different commercial products. The world produces chemicals—faster than it can manage.

These chemicals include extremely toxic substances which can cause allergies, damage vital organs of the human body like the eye, brain, liver, kidney and reproductive organs, produce deformities in babies during pregnancy and promote cancer. In the case of accidental release into the environment in large quantities, as in the case of Bhopal, they can lead to mass murder. What is amazing is that we know nothing about the toxic effect of 80 per cent of the chemicals used.

Industries which produce potentially toxic and hazardous wastes are pesticides, dyes and pigments, organic chemicals, fertilisers, non-ferrous metals, steel and chlor-alkali manufacturing plants.

The major locations of such industries are Delhi, Udaipur, Kanpur, Chandipur, Bokaro, Jamshedpur, Rourkela, Kolkata, Raipur, Ahmedabad, Baroda, Mumbai, Hyderabad, Visakhapatnam, Bangalore, Chennai and Cochin. Bhopal is not included in the list, which shows that unlisted factories can cause major disasters.

Table 3.5: *Toxic chemicals—uses and hazards*

Name	***Uses***	***Hazards***
Arsenic	Pesticides/Unani medicines/Glass	Toxic/Dermatitis/Muscular paralysis/Damage to liver and kidney/Loss of hair/ Gangrene/Cancer
Asbestos	Roofing/Insulation/ Air-conditioning roofs/ Plastics/Fibre/Paper	Carcinogenic to workers and family members
Benzene	Gasoline additive/ Manufacture of many chemicals	Leukemia/Chromosome damage
Beryllium	Aerospace industry/ Ceramic parts/ Household appliances	Fatal lung disease/ Heart and lung toxicity
Cadmium	Electroplating/Plastics/ Pigments/ Superphosphate fertilisers	Kidney damage/ Carcinogenic
Chlorinated organics (DDT, BHC, etc.)	Pesticides/ Fungicides	Nervous depression/ Carcinogenic
Chromates	Tanning/Paints/ Pigments/Corrosion inhibitors/Fungicides	Skin ulcers/Kidney inflammation/ Carcinogenic
Lead	Pipes/Storage batteries/ Paints/Printing/Plastics/ Gasoline additive	Neurotoxin/Blood-system and brain damage

Contd...

Name	***Uses***	***Hazards***
Manganese	Mining/Welding/Dry cell battery/Ferromanganese material (alloy)	Nerve damage/Damage to reproductive system
Mercury	Chloralkai cells/ Fungicides/ Pharmaceuticals	Nerve damage/Kidney damage/Fatal effect of alkyl mercury
Polychloro-biphenyls (PCB)	Transformers/ Insulation of electricity	Carcinogenic/Nerve, skin and liver damage
Sulphur dioxide	Sugar industry	Irritation to eyes and respiratory system/ Damage to plants/ Damage to marble structures, monuments, etc.
Urea	Fertiliser	Bronchial problems/ Kidney damage
Vinyl chloride	Plastics/organic synthesis	Toxic/Carcinogenic

Phosphatic fertiliser factories and thermal power plants generate large quantities of conventional solid wastes which are stored near the sites. Some 5 million tonnes of byproduct phosphogypsum are generated at 12 major phosphatic fertiliser plants. Twenty per cent of this waste is used to produce ammonium sulphate, while the rest containing thousands of tonnes of heavy metals and toxic metals such as chromium, copper, lead, manganese and fluorides are dumped into low lands for land filling or into lagoons in the form of *slurry*.

Thermal power plants, which produce more than 50 per cent of electricity generated in India, are the other major sources of solid wastes. Flyash, the solid waste, accumulates in mountainous heaps near the power stations or carried as slurry into ponds and rivers where it creates serious water pollution problems. Flyash itself contains toxic metals such as beryllium, cadmium, zinc, arsenic, manganese, etc.

From pesticide industries, some 15 tonnes of DDT and 25 tonnes of BHC (hexachlorobenzene) are carried as wastes every year which ultimately travel in the environment, enter our food chain and finally enter our body tissues where they are retained. Indians have shown maximum DDT content (25 ppm) in body tissues in the world. For the last 40 years, DDT has been banned in the western countries but it is still being used as before in India.

3.5.2 Occupational Hazards

Workers in mines, factories, commercial firms, forestry and agriculture are exposed to risks, high to low, which are called the *occupational hazards*. According to the United Nations, some 2 lakh workers die each year throughout the world due to accidents and occupational diseases. Another 10 millions suffer from non-fatal injuries.

3.5.3 Deadly Dust

The worst occupational diseases are caused by dust. These are broadly termed lung diseases (pneumoconiosis) and their effect depends on the nature of dust, its fineness, concentration, period of exposure and the victim's health.

3.5.4 Silicosis

It originates from dust containing free silica or silicon dioxide. It was first reported in 1947 in India in the Kolar gold mines and then found to occur in various other mines and industries—coal, mica, silver, lead, zinc and manganese mines and pottery and ceramics, sand blasting, metal grinding, building construction, rock mining, iron and steel industry and others.

In Jharkhand's mica mines, 33 per cent workers suffer from silicosis. The slate pencil factories in MP villages employ the entire village population where people do not survive

beyond 40 years. Children have to work to support their mothers and often succumb early to the diseases. According to an NGO report, the workers "sign their own death warrants for economic reasons."

3.5.5 Asbestosis

Asbestos is the Greek expression for "unquenchable". Because of its versatility—it resists heat and moisture—it is largely used in home construction, insulation of buildings and ships and also in car-brake linings. Besides, it finds some 3,000 different industrial applications where it has to be processed into proper size. The finest fibres, invisible to the naked eye, are the most dangerous as they find ready access to our respiratory tract, line the air tubes and accumulate in the lungs.

The silica dust (from asbestos fibres), deposits in the lungs, causes pulmonary fibrosis leading to respiratory problems and death—in severe cases, it causes cancer of the air tubes and gastrointestinal tract. In UK, people living within 1 km of an asbestos factory were reported to be suffering from cancer. What is really alarming is that cancer may strike 5–10 years after exposure.

3.5.6 Byssinosis

Some 2 million textile and cotton mill workers are victims of byssinosis. Cotton emits lots of dust in various stages of its processing. The disease strikes 10 years after exposure. It progresses step by step, starting from temporary sickness of wheezing and coughing to permanent breathlessness which shortens life span. Incidence of byssinosis from 6 to 20 per cent has been reported in cotton textile mills in Ahmedabad, Mumbai, Delhi, Kanpur, Chennai, Madurai and Nagpur.

3.5.7 Pneumoconiosis

It is commonly associated with mines and known as the source of "black lungs". Coal mine workers who are long ex-

posed to coal dust lose their capacity to work hard and succumb to the disease which leads to tuberculosis and death.

3.5.8 Child Labourers

India has a bad image abroad for employing the largest number of child labourers (16–18 million/age group 8–14). The International Labour Organisation (ILO) reports that the child labourers are underpaid (Rs 2.00–6.00 per day) for 12–16 working hours and they have to toil under inhuman conditions. The brass industries of UP, carpet industries of Kashmir and match factories of Chennai mostly employ the child labourers. The "Sivkasi" match factories (in Chennai) employ some 50,000 children (8–12 years old), 80 per cent being girls, who work for 14 hours a day under inhuman conditions. Most of them are vulnerable to accidents and do not live beyond 40 years.

Epidemiology

Hippocrates' suggestion over 2000 years ago that environmental factors can influence the occurrence of disease is believed to be the origin of epidemiology. However, it was not until the middle of the 19th century that the distribution of disease in specific human population groups was measured to any great extent. The first epidemiological study was made by Snow in 1854. He identified that the risk of cholera in London was related, among other things, to the drinking water supply by a particular company in London. On the basis of epidemiological studies, Snow suggested that cholera was spread by contaminated water.

Following Snow's work, public health measures, such as improving water supply and sanitation, have made notable contributions to the health of populations. Since 1854, epidemiological studies have provided the information required to identify the measures to be taken.

Epidemiology may be defined as the study of the distribution and determinants of health-related states of events in specified populations and the application of this study to the control of health problems.

Hygiene

Hygiene is closely related to epidemiology. It is defined as the science of health that includes all factors which contribute to healthy living. The purpose of hygiene is to allow man to live in healthy relationship with his environment.

Personal hygiene includes all those factors which influence the health and well-being of an individual. It comprises day-to-day activities for rigorously observing the elementary rules of hygiene for keeping ourselves physically fit and mentally alert through neat and clean habits as our way of life. Our daily routine should involve maintaining regular habits, e.g., taking meals at regular hours, body care (bath, wash, care of teeth, nails and hair, exercise, etc.), use of neat and clean dresses, work and sleep at fixed hours, etc. In other words, we should enforce strict discipline and hygiene in our daily lives. Any disruption of such activities will affect our health. For example, improper care or negligence of teeth leads to pyorrhoea and dental caries (cavities); dirty skin gives scabies, eczema, dermatitis and fungal infection; lack of sleep causes loss of concentration, mental depression and inability to work with vigour; dirty nails are home for ova of intestinal parasites, etc. The habit of washing hands with soap and water before eating will reduce the risks of diseases such as diarrhoea, dysentery, etc.

Health and Disease

According to the World Health Organisation (WHO), health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.

Diseases are due to disturbances in the delicate balance between man and his environment. Three ecological factors are responsible for a disease—Agent, Host and Environment. The disease agent is identified in a laboratory. For example, hepatitis can be identified by the presence of antibodies in blood in a laboratory. The host (patient) is available for clinical examination. But the environment from which the patient comes is mostly unknown. The prevention and control of a disease depends on the knowledge of environment. Without the knowledge of environment, it is difficult to cure the disease.

Depending on the sources, diseases can be classified under the categories—(i) Water-borne disease, (ii) Air-borne disease, (iii) Food-borne disease, and (iv) Vector-borne disease, which have water, air and food, respectively as the sources for (i)–(iii). In the case of vector-borne disease, it is transmitted by various vectors such as mosquitoes, flies or animals. Various agents like viruses, bacteria, parasites are responsible for the diseases. Some common diseases are tabulated in Table 3.6.

Table 3.6: *Some common diseases*

Type	*Disease*
Vector-borne disease	Malaria, Filaria, Encephalitis, Dengue, Kala-azar, etc.
Water-borne disease	Cholera, Bacillary dysentery, Amoebiasis, Diarrhoea, Viral hepatitis, Poliomyelitis, Typhoid, etc.
Air-borne disease	Influenza, Measles, Chicken pox, Asthma, Bronchitis, Pneumonia, Tuberculosis, etc.
Food-borne disease	Cholera, Dysentery, etc.

3.6 AIR POLLUTION

Pure air is colourless and odourless. But various pollutants from natural and man-made sources are entering the atmosphere daily and these disturb the dynamic equilibrium in the atmosphere. This leads to air pollution when the normal properties of air are upset and both man and environment suffer.

Natural sources of air pollution are:

- Volcanic activity, vegetation decay, forest fires emitting carbon monoxide, sulphur dioxide and hydrogen sulphide and tiny particles of solids or liquids sprayed from the seas and land by wind.

Man-made sources are:

- Gases, mists, particulates and aerosols emitted by industries and other chemical and biological processes used by man.

3.6.1 Primary Pollutants

There are five primary pollutants which together contribute to more than 90 per cent of global air pollution:

Carbon monoxide, CO
Nitrogen oxides, NO_X
Hydrocarbons, HC
Sulphur oxides, SO_X
Particulates.

Transportation accounts for more than 46 per cent of the total pollutants produced per year and hence remains the principal source of air pollution. Carbon monoxide is the major industrial pollutant, with a tonnage matching that of all other pollutants together. However, particulate pollutants, though minor, are the most dangerous among the primary pollutants (100 times more harmful than carbon monoxide).

Table 3.7: *Primary air pollutant sources and their quantities (million tonnes per year)*

Sources	*Weight of pollutants produced**				*Particulates*		*Total weight of pollutants produced*
	CO	NO_X	*HC*	SO_X	*< 20μ*	*> 30*	
Transportation	70	10	10.8	0.8	1.2	1.0	94
Fuel combustion (stationary sources)	1.2	11.8	1.4	21.9	4.6	1.3	42.2
Industrial processes	7.8	0.7	9.4	4.1	6.3	2.7	31.0
Solid waste disposal	7.8	0.8	1.6	0.1	1.1	—	11.2
Miscellaneous	8.5	0.4	6.3	0.1	1.3	—	16.6
Total weight of pollutant produced (in million tonnes)	95.0	23.6	29.5	27.0	—	19.5	194.6

1μ = 10^{-6} metre (1 part in 1 million parts of 1 metre)

**Chemical names— see top of this page*

The above data are taken from those in USA (1990). As a matter of fact, USA and other developed countries contribute most to air pollution.

3.6.2 Carbon Monoxide, CO

It is a colourless, odourless and tasteless gas which is injurious to our health. Each year 350 million tonnes of CO (275 million tonnes from human sources and 75 million tonnes from natural sources) are emitted all over the world in which USA alone shares 100 million tonnes. Transportation accounts for 70 per cent of CO emission. That is to say, diesel and petroleum engines in automobiles are primarily responsible for about 70 per cent of CO emissions.

The sources of carbon monoxide, CO, are the chemical reactions:

(i) incomplete combustion of fuel or carbon containing compounds:

$$\underset{\text{(carbon)}}{2C} + \underset{\text{(oxygen)}}{O_2} \longrightarrow \underset{\text{(carbon monoxide)}}{2CO}$$

(ii) reaction of carbon dioxide and carbon-containing materials at elevated temperatures in industries, e.g., in blast furnaces:

$$\underset{\text{(carbon dioxide)}}{CO_2} + \underset{\text{(carbon)}}{C} \longrightarrow 2CO$$

(iii) dissociation of carbon dioxide at high temperatures:

$$CO_2 \rightleftharpoons CO + O$$

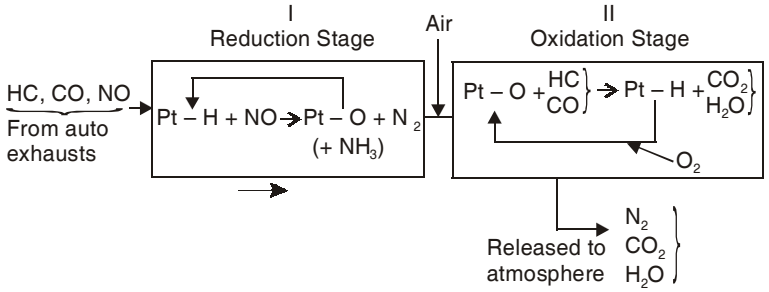
3.6.3 Sinks

Part of carbon monoxide is lost in the upper atmosphere. The major sink is soil micro-organisms. A potting soil sample weighing 28 kg can completely remove in 3 hours 120 ppm carbon monoxide from ambient air. The same soil sample on sterilization failed to remove carbon monoxide from air.

3.6.4 Control of CO Pollution

The petroleum and diesel-fed automobiles account for major share of carbon monoxide emission. Hence, efforts for carbon monoxide pollution control are mainly aimed at automobiles. Use of catalytic converters in the internal combustion engines of automobiles helps in cleaning up the exhaust emissions. Such converters built into the automobile engines promote oxidation-reduction cycles and ensure complete combustion of carbon monoxide, nitrogen oxides and hydrocarbons. The following figure illustrates the action of catalytic converters: use of catalytic converters in two stages helps in the elimination of pollutants from exhaust gases before they are discharged into the atmosphere.

In the first converter, nitrogen oxides are reduced to nitrogen (+ ammonia) in the presence of finely-divided catalyst platinum, and the reducing gases, carbon monoxide and hydrocarbons. The production of ammonia is kept at a minimum under carefully controlled conditions. In the second converter, air is introduced to provide an oxidizing atmosphere for complete oxidation of carbon monoxide and hydrocarbon into carbon dioxide and water in the presence of finely-divided platinum catalyst.



Pt–H = Platinum hydrogen compound;
Pt–O = Platinum oxygen compound;
HC = Hydrocarbon; CO = Carbon monoxide;
NO = Nitrogen oxide; N_2 = Nitrogen;
NH_3 = Ammonia

Fig. 3.4 *Catalytic converters for treating autoemissions*

Thus by means of platinum catalytic converters, autoexhaust emissions are cleaned up through reduction-oxidation reactions. In all developed countries, it is mandatory by law for all automobiles to fit their engines with catalytic converters. In India some automobile companies have plans to fit their automobile engines with catalytic converters.

3.6.5 Nitrogen Oxides, NO_x

It consists of mixed oxides, nitric oxide and nitrogen dioxide (NO and NO_2, respectively)—the former is a colourless and odourless gas but the latter (NO_2) has a reddish brown colour and pungent smell.

The formation of NO and NO_2 is based on the chemical reactions:

$$\underset{\text{(nitrogen)}}{N_2} + \underset{\text{(oxygen)}}{O_2} \overset{1210 - 1765^\circ C}{\rightleftharpoons} \underset{\text{(nitric oxide)}}{2NO}$$

$$2NO + O_2 \rightleftharpoons 2NO_2$$

These reactions occur inside the automobile engines so that the exhaust gases consist of NO_X. The latter concentration in rural air is much less than that in urban air.

In air NO_X is converted into nitric acid ($HNO_{3)}$ by natural processes:

$$\underset{\text{(nitrogen dioxide)}}{NO_2} + \underset{\text{(ozone)}}{O_3} \longrightarrow \underset{\text{(nitrogen trioxide)}}{NO_3} + \underset{\text{(oxygen)}}{O_2}$$

$$NO_3 + NO_2 \longrightarrow \underset{\text{(nitrogen pentoxide)}}{N_2O_5}$$

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

This nitric acid is one of the constituents of acid rain discussed in a subsequent section. From auto-exhaust emissions NO_x is removed as discussed above by means of catalytic converters.

3.6.6 Hydrocarbons and Photochemical Smog

Natural processes, particularly in trees, emit large quantities of hydrocarbons into air. Methane, CH_4, is a major hydrocarbon. It is generated in large quantities by bacteria formed by anaerobic decomposition of organic matter in water, sediments and soil.

$$\underset{\text{(organic matter)}}{2\{CH_2O\}} \xrightarrow{\text{bacteria}} \underset{\text{(carbon dioxide)}}{CO_2\uparrow} + \underset{\text{(methane)}}{CH_4\uparrow}$$

Domestic animals (cattle, buffaloes, etc.) contribute about 85 million tonnes of methane to the atmosphere each year. Automobiles are the significant source of hydrocarbons.

In the presence of ozone, carbon monoxide, nitrogen oxides and hydrocarbon participate in photochemical reactions (in the presence of sunlight). A chain reaction proceeds in which the free radical R $CH_2^{\bullet}$ is generated in the first step. Other free radicals which are formed are: R $CH_2O_2^{\bullet}$ in the second step by reaction with oxygen, R $CH_2O^{\bullet}$; R $CH_2O^{\bullet}$ in the third step by reaction with nitric oxide; $HO_2^{\bullet}$ in the fourth step by reaction with oxygen—a stable aldehyde, R CHO is another product at this stage; $HO^{\bullet}$ is formed in the fifth step by reaction with nitric oxide (nitrogen dioxide is another product here); and finally, the initial free radical R $CH_2^{\bullet}$ is regenerated by reaction with hydrocarbon, R CH_3 thereby sustaining the chain reaction.

The harmful products in the chain reaction are NO_2 and aldehyde, R CHO. A side reaction also follows by another route through the aldehyde, R CHO; it gives an injurious end product, peroxyacyl nitrate (PAN) which is a strong eye irritant. These reactions lead to photochemical smog formation, which is characterized by brown hazy fumes which irritate the eyes and lungs and also cause serious damage to plants.

Photochemical smog occurs in coastal cities in winter climate, e.g., in Los Angeles, USA, which have the heaviest vehicular traffic.

3.6.7 Sulphur Dioxide, SO_2

Sulphur dioxide is a colourless gas with a pungent odour. It is produced from the combustion of any sulphur-bearing material. Sulphur dioxide, SO_2, is always associated with a little of sulphur trioxide, SO_3.

$$\underset{\text{(sulphur)}}{S} + \underset{\text{(oxygen)}}{O_2} \rightleftharpoons \underset{\text{(sulphur dioxide)}}{SO_2}$$

$$2SO_2 + O_2 \rightleftharpoons \underset{\text{(sulphur trioxide)}}{2SO_3}$$

Man-made sources—coal-fired power stations and other industries—contribute about 33 per cent of SO_X pollution while natural sources, viz. volcanoes, provide about 67 per cent of SO_X pollution.

Soot particles containing metal oxides catalyze the oxidation of sulphur dioxide to trioxide.

$$\underset{\substack{\text{(sulphur dioxide)}\\ \text{(ozone)}}}{SO_2 + O_3} \longrightarrow \underset{\text{(sulphur trioxide)}}{SO_3 + O_2} \xrightarrow{H_2O} \underset{\text{(sulphuric acid)}}{H_2SO_4} \longrightarrow \underset{\text{(aerosol droplet)}}{(H_2SO_4)_n}$$

$$SO_2 + \tfrac{1}{2}O_2 \xrightarrow{\text{soot}} SO_3 \longrightarrow H_2SO_4 \longrightarrow \underset{\text{aerosol droplet}}{(H_2SO_4)_n}$$

The first reaction above occurs in the presence of ozone and water vapour. The product, sulphuric acid, is formed on aerosol (fine particle suspended in air as in smoke, fog, mist, etc.) droplet. Sulphuric acid is one of the constituents of acid rain.

In winter, sulphur oxides from thermal power plants along with other gases lead to *smog* formation, e.g., *London smog*. This is known as reducing smog in contrast with photochemical smog which is known as *oxidising smog* (consisting of hydrocarbons, nitrogen oxides and ozone). *London smog* (1952) is well-known for its disastrous effect. Heavy smog (SO_2) conditions prevailed in London for five days which killed about 4,000 people. The causes of death were bronchitis, pneumonia, and other respiratory troubles particularly among aged people.

3.6.8 Control of SO_x Pollution

SO_x (sulphur oxides) from flue gases of industrial plants can be removed by means of chemical scrubbers. The flue stack gases are led through a bed of (slurry) limestone, $CaCO_3$ (calcium carbonate) which absorbs sulphur dioxide quite efficiently.

$$\underset{\text{(calcium carbonate)}}{2CaCO_3} + \underset{\text{(sulphur dioxide)}}{2SO_2} + \underset{\text{(oxygen)}}{O_2} \longrightarrow \underset{\text{(calcium sulphate)}}{2Ca\,SO_4} + \underset{\text{(carbon dioxide)}}{CO_2}$$

The method is economical but the disposal of solid waste, calcium sulphate is a problem.

Alternatively, sulphur oxide in aqueous solution is treated with citric acid salt and the resulting solution is exposed to a stream of hydrogen sulphide gas whereby sulphur is deposited. This sulphur can then be recovered and utilised.

Thermal power plants, major sources of man-made SO_X pollution, are normally constructed with tall chimneys to disperse the emissions over a wide area. This reduces the local problem but creates problems for far away areas through acid rains (*see* Fig. 3.5).

3.6.9 Acid Rain

It has been described above that much of nitrogen oxides (NO_x) and sulphur oxides (SO_x) entering the atmosphere are transformed into nitric acid (HNO_3) and sulphuric acid (H_2SO_4), respectively. These combine with hydrogen chloride (HCl) from HCl emissions (both by man-made and natural sources) and generate acidic precipitation, known as *acid rain*.

Acid rain is a major environmental issue as it badly damages the environment. It damages buildings and structural materials of marble, limestones, slate and mortar. These materials become structurally weak as calcium carbonate reacts with sulphuric acid to form soluble sulphate, which is leached out by rain water:

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

(limestone) (sulphuric acid) (calcium sulphate)

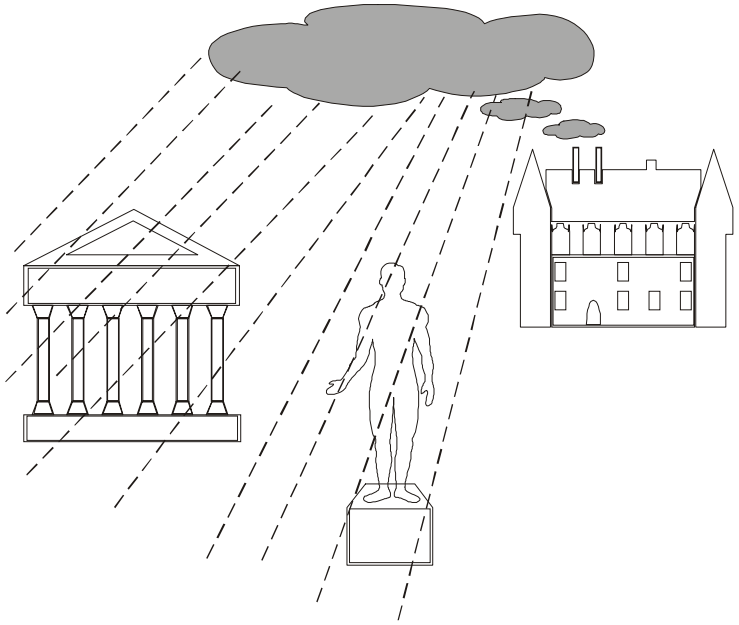


Fig. 3.5: *Acid rain in Greece and Italy*

In Greece and Italy, invaluable stones and statues have been partly dissolved by acid rain. Besides these, acid rain damaged forests in Germany and lakes in Sweden and Canada. Acid rain originated from U.K., but far away in Sweden it damaged some 8,000 lakes of which 4,000 are dead. Similarly, acid rain from USA damaged lakes and forests in Canada. In India, the Taj Mahal is threatened by acid rain from Mathura Refinery and other industries.

3.6.10 Control of Acid Rain

Acid rain can be checked if its constituents, sulphur oxide and nitrogen oxide, are controlled as discussed above.

3.6.11 Particulate Matter

Small solid particles and liquid droplets are collectively termed *particulates*. They originate both from natural and man-made sources. Every year natural sources discharge 800–2,000 million tonnes and man-made sources 200–500 million tonnes of particulates. Among man-made sources, flyash from thermal power plants deserves mention. Table 3.8 gives a list of annual production of particulate matter from the two sources.

Table 3.8: *World-wide addition of particulate matter to the atmosphere (in million tonnes)*

Particulate matter	*Annual production*	
	Natural source	*Man-made sources*
Total particles	800–2000	200–450
Dust and smoke	—	10–90
Salt, forest fires	450–1100	—
Sulphate	130–200	l30–200
Nitrate	30–35	140–700
Hydrocarbons	15–20	75–200

Particulates range in size from 0.0002 μ (about the size of a molecule) to 500 μ (1 $\mu = 10^{-6}$ metre). 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 (urban/industrial area).

3.7 OZONE HOLE

In the stratosphere, the second layer of the atmosphere, ozone is present in small quantities as a protective shield for the earth. Ozone strongly absorbs ultraviolet radiation from the sun (295–320 nm) which is injurious to life on earth. Thus, it protects living species on earth. But recent human activities have injected some dangerous chemicals into the

stratosphere which consume ozone and reduce its concentration. This is the phenomenon of *ozone hole* in the stratosphere.

Exhaust gases from jet aircraft and artificial satellites discharge nitric oxide (NO), nitrogen dioxide (NO_2), etc. which immediately react with ozone.

$$\underset{\text{(ozone)}}{O_3} + \underset{\text{(nitric oxide)}}{NO} \longrightarrow \underset{\text{(oxygen)}}{O_2} + \underset{\text{(nitrogen dioxide)}}{NO_2}$$

$$O_3 + NO_2 \longrightarrow O_2 + \underset{\text{(nitrogen trioxide)}}{NO_3}$$

Chloroflourocarbons (CFC) are used as coolants in refrigerators and air-conditioners. These slowly pass from troposphere to stratosphere and once there, they stay there 100 years. In the presence of ultraviolet radiation (200 nm) from the sun, CFC breaks up into chlorine-free radical (Cl) which readily consumes ozone.

$$CFCl_3 \xrightarrow[\text{ultra-violet radiation}]{h\nu} CFCl_2 + Cl^{\bullet}$$

$$Cl^{\bullet} + O_3 \longrightarrow ClO^{\bullet} + O_2$$

$$ClO^{\bullet} + O \longrightarrow Cl^{\bullet} + O_2$$

The free radical ($Cl^{\bullet}$) is regenerated and continues the chain reaction. It is estimated that one molecule of CFC consumes one lakh molecules of ozone. The damage by CFC continues for 100 years. Even if CFC production is stopped now all over the world, the CFC that is already there in the stratosphere will continue to damage the ozone layer for the next 100 years.

In 1979, ozone hole was observed in the sky over Antarctica—here ozone layer thickness was reduced by 30 per cent. Later on ozone hole was discovered in the sky over the thickly populated northern hemisphere. Here in winter ozone thickness was reduced by 4 per cent and in summer by 1 per cent.

Ozone hole allows passage of ultraviolet radiation to the earth where it causes skin cancer, eye-sight defect, genetic disorder, etc. in the biosphere (man, animal and plant). In Europe and USA there is an increase in the cases of skin cancer among people while some million people are suffering from eye cataract.

In Montreal Conference (*Montreal Protocol*, 1987) and London Conference (1992), it was decided that the developed countries would totally ban CFC production by 2000 and the developing countries by 2010 AD. But as stated above, even after the ban is enforced, the CFC and Cl shall continue their havoc for another 100 years. Researches are on for the development of CFC-substitutes as coolants for refrigerators and air-conditioners.

3.8 ANIMAL HUSBANDRY

India has a huge livestock population—cattle, sheep and buffaloes in the world context. They provide us milk, meat and their excreta are rich source of animal fertiliser for agriculture. They should be treated as valuable animal resources and their farm should be managed well as a matter of national policy. Chicken, duck and pigs may also be included in the list. Poultries and piggeries are important for the economy.

It may be noted that cattle dung, buffalo dung and their urine are rich source of methane, an important greenhouse gas.

It is essential that livestock population be brought under family planning and reduction by about 25 per cent to keep the environment clean.

B. Current Environmental Issues

3.9 POPULATION AND ENVIRONMENT

Population is intimately related to environment. The Human population has grown faster in the 20th century than ever before. World population doubled in 40 years between 1950 and 1990 to cross five billion. The developed countries account for 1.5 billion and developing countries 3.5 billion population. By 2010 AD the population has touched 6.3 billion and by 2100AD it will grow to 7 billion (one in every seven will be an Indian). World population is growing by 92 million every year, roughly adding population of Mexico.

It is interesting to note that it took about 2-million years for the world population to become 1 billion (1830), 100 years for 2 billion (1930), 30 years for 3 billion (1960), 15 years for 4 billion (1986) and 11 years for 5 billion (1997). The population stands at 6.3 billion (2000) and is estimated to be about four times around 22.5 billion in 2100. In developed countries the population is likely to be less than double while in developing countries like India about four times (2100).

The statistics for India is of serious concern. Between 1901 and 1951, India's population grew from 238 million to 361 million, an increase of 52 per cent in 50 years. Between 1951 and 1981, it expanded from 361 to 685 million. Post-independent India in 35 years (1947–81) literally added a second India, i.e., doubled its population. In 2000, it touched 1 billion mark and is the second most populous country, next to China (May 11, 2000). We have been overwhelmed by population explosion since 1980.

According to 2001 Census Report, India has joined *one billion club*, with population of 1.02 billion, ranking second to China (1.265 billion). By 2025, India is likely to overtake China and will be the most populous country in the world. It has to be noted that while Chinese population is under

control with growth rate of 0.7 per cent, India's population growth rate is 1.8 per cent at present. While China with its strong economy can support its 1 billion plus population, India cannot afford to do so, being one of the poorest countries in the world (400 million people live below the poverty line). We are overwhelmed by the population explosion since 1980 and that remains the core issue of our environment and economy.

Indian population statistics

1901	1951	2001
238 million	361 million	1020 million

3.9.1 Distribution

For historical and other reasons people are not uniformly distributed. USA and Canada have a population of 250 million; South America and the former Soviet Union (CIS) have the same population; Africa and Western Europe have about 500 million people; East Asia, i.e., China, Japan and Korea have more than 1 billion while South Asia is the most populous region, 1.5 billion (India, Bangladesh, Pakistan more than 1 billion). India is adding every year the population of Australia at the current rate.

3.9.2 Population Density

The density of population within a country gives a rough idea of the effect of population on natural resources. In general, lightly populated countries retain more of their original vegetation and wild animal populations than those with dense human population. Thus, Australia (4 people/sq. km.) is not likely to face wood or water shortage compared to Bangladesh (1800 people/sq. km.). However, total population size or population density cannot accurately predict the impact of environmental damage on the economy of a country. Some of the most crowded countries in East and South Asia are the most prosperous, e.g., Taiwan, South Korea, Hong Kong and Singapore where the population density is 1000 people/sq. km.

Some crowded countries can even manage to produce all their own food. U.K. (600 people/sq. km.) exports food while Brazil (44 people/sq. km.) has to import food. Again, Europe has all the timber and freshwater it requires but Africa (95 people/sq. km.) has acute shortage of both these items.

Some differences among countries as stated above are due to differences in their economies—sustainable and non-sustainable. The countries with stable population enjoy sustainable economy and are prosperous—the developed countries belong to this category. Similarly, countries with fast population growth suffer from non-sustainable economy and face serious problem.

3.9.3 Age Structure

In contrast to the developed countries, India has a pyramidal distribution of age-wise population distribution. Children constitute 40 per cent, youth 33 per cent, middle-age persons 21.5 per cent and old-age persons 6.2 per cent. Such a structure with predominantly young people up to 34 years (73 per cent) favours fast population growth. While India has a youthful age (reproductive group) structure, in the Western countries the population has much less youthful age structure which slows the population growth.

The ratio of people over 65 and under 15 to the rest of the population is *dependency ratio*. This gives a measure of the economic impact of the population age structure. People above 65 and below 15 contribute little to the economy and must be supported by the working population. Dependency ratios are rising in developing countries. High dependency ratios, as in India, have adverse effect on the economy. This explains why working Indians have lower standard of living compared to developed countries.

3.9.4 Doubling Time

The period within which the population of a country doubles is known as its doubling time. This gives some idea

of the adverse effect of population growth. Most developed countries have doubling times of more than 100 years while in developing countries, as in India, population has doubling time less than 25 years. It is absurd to double our resources—water, food and energy in 25 years and tackle the pressure on schools, hospitals, police protection and other vital services.

3.9.5 Fertility Rate

The general fertility rate of a population is the number of babies born to 1000 women of the reproductive age. The rate of population growth, however, is based on the average age of first reproduction. Thus, whether a population is increasing, decreasing or stationary is more correctly estimated from the age-specific fertility rate, the number of births per 1000 women of each reproductive age group. The fertility rate for India and other developing countries is about 3.0 while that for the Western countries is below 1.5.

3.9.6 Infant Mortality/Life Expectancy

The death rate is generally expressed as the number of deaths per year for every 100 people. Modern medical science has helped to reduce the death rate but not the birth rate. Death control without birth control has led to population explosion.

Infant mortality is one of the most tragic indicators of poverty of a country. It also sets the parameter of *life expectancy*, i.e., the average number of years that a new-born baby is expected to survive. Progress in medical science has in general increased the life expectancy. In 1900, life expectancy was 46 years in the developed countries because the infant mortality was high, i.e. 40 per 1000. The situation improved much in 1984 in these countries when the life expectancy rose to more than 70 years as the infant mortality dropped to about 10 per 1000. The world's highest life

expectancy is that of Japan (79 years) which enjoys highest literacy and fairly high standard of living. In the developing countries high infant mortality accounts for lower life expectancy. Furthermore, lack of the basic amenities of life (access to clean water, nutritious food and elementary education) is responsible for life expectancy of 45 years in most of Africa whereas in South America and East Africa life expectancy rose to 65 years.

It is on record that in developing countries 1 in 3 children is malnourished and about 3 million children die annually from diseases that could be avoided by immunization. And moreover, 1 million women die each year from preventable reproductive health problems.

3.9.7 Carrying Capacity

The maximum population size that an ecosystem can support under particular environmental conditions is known as the *carrying capacity*. In natural ecosystems with unlimited resources and ideal environment, species can multiply at a maximum rate. However, in actual practice, the population of a species remains in check due to interaction of the inhabiting species as also finite nature of resources.

If the prevailing agricultural system produces X calories and if each person needs a minimum of Y calories to survive, then the carrying capacity of the system is given by X/Y.

It is an established fact that while foodgrain production is under optimum conditions increased arithmetically (1, 2, 3, 4, ...), population increases geometrically (2^2, 3^2, 4^2 ...).

$$\frac{dN}{dt} = rN$$

where dN/dt = rate of population growth

N = population size,

r = specific growth rate

With doubling of population, resources do not double and hence set in a critical situation. If the population size far exceeds the carrying capacity by a wide margin, it leads to *population crash* when environmental conditions get degraded and lower the carrying capacity.

The earth weighs about 5.97×10^{24} kg. If the present population growth continues for the next 5000 years, then the weight of human population itself will equal the earth's weight. In other words, another earth will have to be accommodated within this earth, which is totally absurd. This implies that man will run out of space and resources. Thus, the present population growth will get more and more unfavourable conditions for human survival as it will destroy the carrying capacity in the long run.

3.9.8 Population Stabilisation/ Sustainable Development (Indian Context)

India accounts for 16 per cent of the world population but only 2.4 per cent of the land area. Hence, per capita availability of land in the country is 0.48 hectare as against 4.14 hectares in USA, 8.43 hectares in CIS and 0.98 hectares in China. Our population is concentrated in the river valleys (40 per cent in the Ganga basin). Man:land ratio in relation to arable land is only 0.27 hectares in India which is quite low for a predominantly agricultural country.

The concept of carrying capacity, as stated above, implies that only a limited number of people can be supported by the resources of a country. Due to demographic (population) pressure, economic pressures build up while cropland, grassland, woodland and fisheries that support the human population by supplying goods and services are adversely affected. As people multiply, resources obviously shrink. The future population growth has to be related to the resource base in order to have sustainable development. Population

stabilisation (i.e., keeping the population level low, preferably below 0.5 per cent as in the developed countries) is the key to economic development and resource management. This is the success story of all developed countries.

Population explosion is a time-bomb which must be defused sooner or later. It is one of the major crises the nation is facing. We have to break the vicious **P-triangle**—Population–Poverty–Pollution—on an emergency basis for our own survival.

3.9.9 Kerala Model

Kerala has earned the distinction of lowest birth rate among Indian states since 1960—25 per 1000 as against 33 per 1000, Indian average. It is comparable, as a state, to West Bengal—both are densely populated, both have emphasis on education and both are under similar political system of long periods of rule by left-oriented parties. But the comparison ends here. Kerala is poorer than West Bengal (per capita income, both urban and rural, less than West Bengal), less industrialised than West Bengal and has greater inequalities in income. Yet Kerala's birth rate is lower than that of West Bengal since 1960. This belies the general feeling that greater industrialisation and incomes lead to lower birth rates. The success story of Kerala is explained below.

The reasons behind the low birth in Kerala are—higher age of marriage for women, at 21 years (Indian average 17 years); higher female literacy rate 53 per cent (Indian average 13 per cent); greater emphasis on primary education (education budget 60 per cent spent on primary education/ West Bengal 38 per cent); better public distribution system of food among 97 per cent of population; better health facilities in rural areas and greater success of family planning programmes. Thus, Kerala shows the way to population stabilisation in India.

3.9.10 Women and Environment

Women, particularly poor village women, are the worst victims of environmental degradation. Their day starts with a *long march* in search for fuel, fodder and water. Many such women spend up to 10 hours a day fetching fuel, fodder and water. An average family in Karnataka village walks about 5 km daily on average for collecting fuelwood only, equivalent to walking from Delhi to Mumbai every year. In deforested hill and forests the treks are longer and more difficult. By lighting firewood in chullahs, they turn their kitchens into gas chambers where they spend 2-3 hours daily for cooking food. They are exposed to heavy fumes and smoke and suffer as much as a chain smoker smoking 20 packets of cigarettes a day.

Biomass plays a crucial role in meeting daily needs of the vast majority of rural households. The different forms of biomass are food, fish, fuel (firewood, crop wastes and cowdung); fodder, fertiliser for agricultural fields (cowdung, organic manure, forest wastes); building materials (timber and thatch) and medicines (herbs). The country's biomass base is affected by deforestation and loss of vegetation cover. It is the village women who are worst hit by deforestation and devegetation (loss of vegetation cover). Similarly, the forest dwellers, viz. tribals and nomads (those who wander from one place to another and have no fixed location) face total social destruction—they are converted into the uprooted lot of "*environmental refugees*".

3.9.11 Woman Power

In the 18th century, some 350 Bishnoi men and women from the Bishnoi community in Rajasthan were determined to protect their forest. They clasped the trees when the Maharaja of Marwar sent some wood-cutters along with soldiers to cut down those trees which were required for a

brick kiln (furnace) to make slabs for his palace. But the group of men and women resisted by continuing to clasp the trees and finally they were hacked to death. This was the precursor (forerunner) of the **Chipko Movement** two centuries later (1983).

The women of the Garhwal hill region of Uttarakhand were at the vanguard of the Chipko Movement (*see* Section 4.4.1). They organised and executed the movement with utmost sincerity and spread their base all over the Garhwal region. Thus, organised woman power prevented further ecological crisis in the Himalayan region.

Another shining example of woman power was the case of Khirakot women in Almora district of Uttarakhand Himalayas. A Kanpur contractor was setting up soapstone mines in the hills and thereby destroying the ecology of the region. The Khirakot women sprang into action—they got organised, stopped the work of the mines and also fought legal case against the contractor. Finally they won the battle, both legal and environmental, and got the contractor's license cancelled.

3.9.12 Human Development

The economic status of a country is normally judged by its Gross Domestic Product—GDP (consumerism, i.e., commodities purchased per year, consumer durables, financial status). But since the 90s, the United Nations has introduced the concept of *Human Development Index*—HDI replacing GDP. This is an estimate of human resources development as measured by three parameters—life span, literacy and standard of living. It determines the quality of life in a country. All the countries in the world have been listed in terms of HDI.

The latest United Nations Report (2000) on Human Development and HDI list reveals some interesting facts

and figures regarding the status of India in the world perspective.

India has moved up by four places from 132 to 128 in the HDI list while Pakistan ranks 135, Bangladesh 146, and Sri Lanka has moved up to position 84. Canada retains the top position (number one) for the seventh consecutive year while Japan has moved down from position number one to eighth during a span of 10 years. The HDI rankings of other countries in the high category are: Norway (number 2), USA (number 3), Australia (number 4), Sweden (number 5), Belgium (number 6), the Netherlands (number 7), Japan (number 8), Britain (number 9) and Finland (number 10).

According to the Report, even in the richest nations relative prosperity in some countries like USA has failed to improve lives. Although USA has the second highest per capita income among 18 richest nations (OECD, i.e., Overseas Economic Cooperation and Development countries), it has a fairly high poverty rate. The main reason is the prevalence of functional illiteracy (20 per cent).

In general, however, the deprivations cast their dark shadow over most of the world. Some *1.2 billion people live below poverty line, with income less than one dollar a day; more than 1 billion people in the developing countries lack access to safe water and more than 2.4 billion people lack adequate sanitation*.

In the HDI list, India occupies 128th position. Per capita GDP (Gross Domestic Product) values for India ($ 300) are less than 1.5 per cent than those of Japan ($ 24,000) and USA ($ 20,000). Inspite of remarkable progress in science and technology, India remains one of the poorest countries in the world, with 40 per cent population living below the poverty line, 44 per cent below literacy line and 25 per cent without access to proper healthcare.

3.10 GREENHOUSE EFFECT (GLOBAL WARMING)

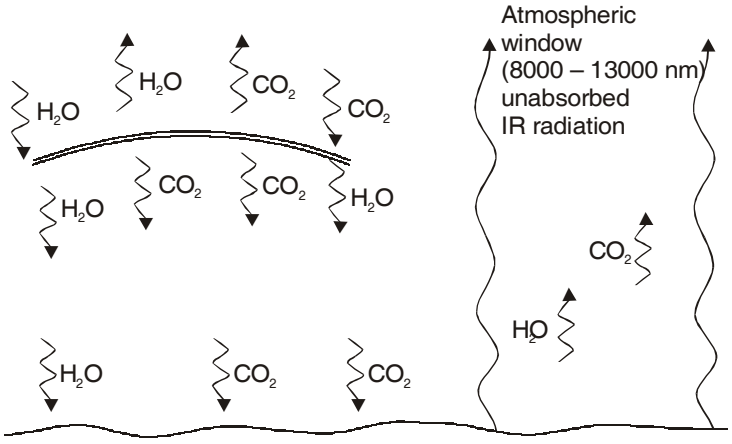
Carbon dioxide is a non-pollutant gas in the atmosphere and a minor constituent (356 parts per million) but it is of serious concern for the environment for its ability to change the global climate.

The earth's surface partly absorbs sun's rays while emitting long-wave infra-red radiation (8000-25000 nanometres; 1 nanometre = 10^{-9} metre = 1 nm). Carbon dioxide and water vapour in the atmosphere strongly absorb infra-red radiation (14,000–25,000 nm) and effectively block a large fraction of the earth's emitted radiation. The radiation thus absorbed by carbon dioxide and water vapour is partly returned to the earth's surface. The net result is that the earth's surface gets heated and the phenomenon is known as the *Greenhouse Effect* (Fig. 3.6).

The carbon dioxide level in air has increased from 280 ppm (pre-industrial revolution era, 1780) to 350 ppm at present in two centuries. Fossil fuel (petrol, diesel, coal) combustion is the major source of increase of carbon dioxide level increasing at the rate of 1–2 per cent per year.

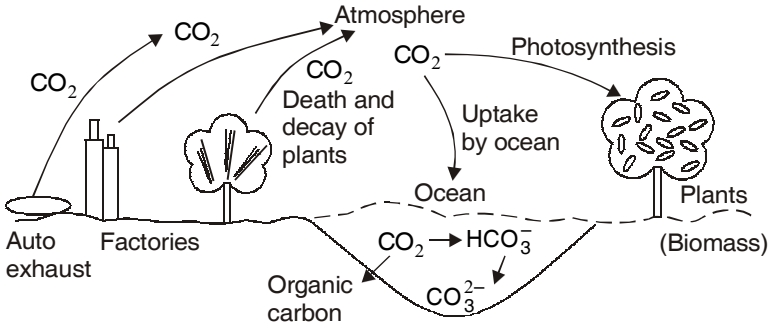
At this rate of increase, the earth's surface temperature may rise as much as 2°C in the next 100 years. However, nature has its check and balance system. The rate of increase of carbon dioxide is only 50 per cent of its expected magnitude due to the sinks, viz. oceans and photosynthesis by green plants (Fig. 3.7).

It may be noted that a slight rise in temperature, even by 1°C, can have adverse effect on the world food production.



H_2O = Water, CO_2 = Carbon dioxide

Fig. 3.6: *The greenhouse effect*



CO_3^{2-} = Carbonate, HCO_3^- = Bicarbonate

Fig. 3.7: *Sources and sinks of carbon dioxide*

1. Thus, wheat-producing zones in the northern latitude will be shifted from CIS (former USSR) and Canada to the north pole and in India from UP, Panjab, Haryana to the Himalayas, i.e., from fertile to non-productive soil. In other words, wheat production will badly suffer.

2. The biological productivity of the ocean will fall due to warming of the surface layer. This reduces transport of nutrient from deeper layers of the ocean to the surface by vertical circulation. Moreover, there will be less photosynthesis by marine plants. In other words, the production of sea food (marine plants and fish) will decline. Sea food constitutes more than 30 per cent of our food supply.
3. Another disastrous effect is the rise in sea levels by as much as 15 cm in the next 100 years due to partial melting of polar ice caps. This sea level rise would threaten coastal cities (Kolkata, Mumbai, Chennai, etc.) and some 60-odd island nations such as Maldives, Bangladesh, etc. which will be drowned under the sea. When Himalayan snow will melt and get exhausted, the Himalayan rivers including Ganga may dry up—the Ganga valley will be hot and north India will lose its population base. At the same time, India will lose its major life line, Ganga.

3.10.1 Other Greenhouse Gases

Carbon dioxide is not the only culprit responsible for greenhouse effect and global warming. Other greenhouse gases are: methane, chlorofluorocarbons, nitrous oxide, ozone and water vapour. The relative contributions of these gases to greenhouse effect are:

- Carbon dioxide, 50 per cent; Methane, 19 per cent; Chlorofluorocarbons, 17 per cent; Ozone, 8 per cent; Nitrous oxide, 4 per cent; Water vapour, 2 per cent.

This shows that carbon dioxide accounts for 50 per cent of the greenhouse gases. The shares of methane (19 per cent) and chlorofluorocarbons (17 per cent) (gases from refrigerators and air-conditioners) cannot be ignored.

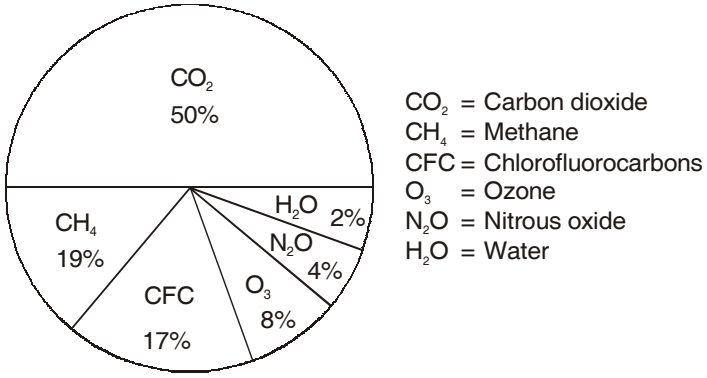


Fig. 3.8: *Greenhouse gases (relative shares)*

Questions

1. What are the causes of water pollution?
   Name the organic and inorganic water pollutants.
2. Write a short note on "Arsenic contamination of ground- water."
3. Give a flow-sheet diagram of municipal waste water treatment (primary and secondary).
4. List water quality parameters for drinking water (USPH Standard) and give their permissible limits.
5. Give an outline of the modes of solid waste disposal.
6. How do you propose solid waste management?
7. Give an account of Love Canal dumpsite incident.
8. Comment on sanitary land-fill method for waste disposal.
9. What are the units of noise measurement?
10. Discuss noise pollution health hazards.
11. What are the permissible levels of noise in (a) residential, (b) business, and (c) sensitive areas?
12. Name some toxic chemicals—their uses and hazards.

13. Write notes on:
    (a) Asbestosis
    (b) Silicosis
    (c) Byssinosis
14. What are primary air pollutants?
15. How would you control carbon monoxide?
16. What is acid rain? How does it damage environment?
17. What is ozone hole? How is it formed? Explain with the reactions.
18. How can ozone hole be controlled?
19. What is population explosion? How does it affect the economy of India?
20. What is meant by doubling time? Explain with reference to world population and Indian population.
21. How is infant mortality related to life expectancy?
22. Write notes on:
    (a) Carrying capacity of the earth
    (b) Population stabilization and sustainable development
    (c) Human development index and India's rank in the world context.
23. Explain greenhouse effect.
24. What are greenhouse gases?
25. How does global warming affect the world climate and food production?

Unit-IV

ENVIRONMENTAL POLICIES— PROTECTION, LAWS

4.1 ENVIRONMENTAL INSTRUMENTS AND INSTITUTIONS

The Central and State governments own, control and develop almost all the country's forests, dams, major irrigation systems, power stations, railways, ports, roads, mines and many industries. The government is not just the protector of the country's environment but it also has the role of destroyer if it neglects its responsibility. The government has immense responsibility for sustaining environmental conscience.

India's active interest in environment was initiated in 1972 when the then Prime Minister (late Smt. Indira Gandhi) attended the United Nations Conference on Human Environment. A National Committee on Environmental Planning and Co-ordination (NCEPC) was created to act as the apex advisory body in the Department of Science and Technology (DST). The Fourth Five Year Plan (1969–74) mentioned the need for comprehensive recognition of environmental issues in any developmental plan. The successor of NCEPC was the Department of Environment (DOEn) in 1980 within the Ministry of Science and Technology, headed by the Prime Minister. The DOEn is the nodal agency to ensure environmental protection, to conduct environmental impact studies of development projects and have the administrative responsibility for

pollution monitoring and control. In 1985, the topics of wildlife and forests were added to the list and a new Ministry of Environment and Forests was created, which remained under the charge of the Prime Minister.

The assignments of the Ministry of Environment and Forests are:

(i) Environmental Laws and Policies
(ii) Environmental Monitoring and Control
(iii) Survey of Conservation of Natural Resources
(iv) Management of Forests and Conservation of Wildlife
(v) Environmental Education, Awareness and Information
(vi) International Co-operation.

The Ministry of Environment and Forests is the government's main instrument for generating eco-consciousness within the government and outside. But with passage of time, it has been found to be bogged down in bureaucracy and to fail to respond to environmental issues. The Ministry has three major units:

(a) Department of Environment, Forests and Wildlife
(b) National Wastelands Development Board (NWDB)
(c) Ganga Project Directorate.

The state governments also set up their own ministries of environment. The Central Prevention and Control of Pollution Board attends to water and air pollution problems at national level while their counterpart state boards are in charge of their respective state issues.

4.1.1 Environmental Policies

The government's environmental policy focuses on the areas:

1. Conservation of natural resources by direct action such as declaration of reserved forests, biosphere, wetlands, mangroves and protection of endangered species.
2. Check further degradation of land and water through Wasteland Management and Restoration of river water quality programmes.
3. Monitoring development through Environmental Impact Assessment Studies of major project proposals.
4. Penal measures for industries which violate Pollution Control Act.

4.2 FORESTS

The policy for conservation of natural resources mainly focuses on the policy for conservation of forests. The latter has undergone various processes of legislation over the last two centuries. Some forests have been declared as Reserve Forests, the first being the Corbett National Park (1936). The National Forest Policy was framed in 1988 for forest management in view of the rapidly vanishing forests which now stand at about 15 per cent forest cover. The Forest Policy aims at 33 per cent forest cover. In the hilly regions, most of the major rivers originate and the ecosystem is fragile—the new policy targets at 67 per cent of land under forest cover, encourages massive afforestation and prohibits deforestation. The role of tribals living in the forests and on forest products has been recognised and their symbiotic (i.e., intimate association) relationship with forests since ancient times has been respected.

4.2.1 Biosphere Reserves

In different regions of the country, several biosphere reserves have been declared for conservation of different

ecosystems. At present, 13 biosphere reserves have been recommended.

4.2.2 Flora and Wildlife

The total area under mangroves in India is about 6750 sq. km, which is about 7 per cent of world's mangroves. Among these, the Sunderbans of West Bengal has the largest area under mangroves, 4200 sq. km, the next being Andaman and Nicobar Islands, 1190 sq. km together accounting for 80 per cent of the total mangroves in the country. The mangroves have suffered severe deforestation, which must be checked.

India is rich in biodiversity with about 75,000 species of animals and 45,000 species of plants. The fauna (animals) include 340 species of mammals, 1200 species of birds, 420 species of reptiles, 140 species of amphibians, 2000 species of fishes, 4000 species of molluscs and 5000 species of insects besides other invertebrates (those without backbones/spines). The flora include 15000 species of flowering plants, 5000 species of algae, 1600 species of lichens, 20,000 species of fungi, 2700 species bryophytes, etc. Rich biodiversity is also observed in wetlands and mangroves which serve as treasurehouses of genetic resources and also as active protective systems. There is cause for alarm when we notice overexploitation of biodiversity and continued habitat (shelter) destruction (deforestation). Extinction of species is on the increase—everyday we are losing one animal and one plant species. Already a large number of plant and animal species are in the list of the endangered species.

4.3 ENVIRONMENTAL LAWS/ACTS

There are more than 200 Central and State laws today that can be interpreted one way or another to protect the environment. Only the more important Laws/Acts are tabulated in the next page.

4.3.1 Forests

1927, Indian Forest Act—Forests were classified as

- Reserve forest
- Protected forest
- Village forest
- Restriction on hunting and authorised establishments of sanctuaries.

1976, 42nd Amendment to the Constitution of India—Forests were transferred from State list to the Concurrent list (i.e., all-India basis).

1980, Indian Forest Act—National Forest Policy

- Prohibits State governments for declaring any portion of forest as non-reserved without approval of Central government.
- Prohibits State government for allotting any forest land or any portion thereof for any non-forest purpose.

1988, Indian Forest Act—Welfare of forest-dwellers is the major objective

- Prohibits lease of forest land to anybody other than the government.
- Conservation, planting and increase of forest cover to an average of 30 per cent across the country.

4.3.2 Wildlife

1927, Indian Forest Act—Restriction on hunting

- Establishment of sanctuaries.

1936, Corbett National Park—First Wildlife National Park Act

- Establishment of Sanctuary—Tiger reserve.

1972, Wildlife Protection Act—Action plan for wildlife objectives

- Management of protected areas and habitat.
- Rehabilitation of endangered and threatened species.
- National conservation strategy.
- Collaboration with voluntary bodies and NGOs.

4.3.3 Water

1927, Indian Forest Act—Prohibits poisoning of water in forests

1948, Indian Factories Act—Restrictions on discharge of effluents into waterbodies

1974, Water (Prevention and Control of Pollution) Act—Setting up of pollution control boards at Centre and States

- Industries required to submit discharge data for effluents.
- Penal provision for non-compliance.

1986, Environment Protection Act (EPA) (Act introduced in the wake of Bhopal Disaster, 1984)—Protection and improvement of human environment and prevention of hazards to humans, plants, animals and property.

The Environment Protection Act (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 set up "Green Bench" courts to attend to Public Interest Litigation (PIL) cases concerning environmental hazards affecting the quality of life of the citizen. The "Green Bench" courts have been empowered to settle the cases quickly and provide legal redress to the citizens.

4.3.4 Air

1948, Indian Factories Act—Protection to workers against hazardous processes.

1981, Air (Prevention and Control of Pollution) Act—Ambient air quality specified.

- Monitoring stations established.

1987, Air Act—Empowers government to close down polluting industries and stop their supply line of water and electricity.

1989, Motor Vehicles Act—Emission standards of carbon monoxide and hydrocarbons specified.

4.3.5 Environmental Impact Assessment (EIA)

Analysis of any possible change in the environmental quality, adverse or beneficial, caused by a developmental project of government or private company, is known as Environmental Impact Assessment (EIA). As a matter of government policy, it is compulsory for any enterprise (government/private) to include EIA in the planning stage of any developmental project and submit it to the Central government for clearance. All major and minor irrigation projects and all highly-polluting industries are subjected to EIA for their initiation.

4.4 ENVIRONMENTAL MOVEMENTS

4.4.1 Chipko Movement

In 1973, the Chipko Movement (*Chipako* means to hug or stick to) was launched by Chandi Prasad Bhatt and Sunder Lal Bahuguna against large scale felling of trees by timber contractors in the Uttarakhand hills (formerly in UP). The starting point was Chamoli district of Garhwal region in Uttarakhand. A unique feature was that local hill women from villages were organised and made aware of the ecological threat in the hills. They took active part in the campaign—they embraced trees when the timber contractors reached and compelled them to leave. This novel campaign of saving hill forests and greenery soon spread all along the hill region and to Karnataka in the south in 1983 where it was named "Appiko".

In course of time the Chipko movement crossed geographical boundaries and observed as Chipko Day at New York, USA on April 29, 1983. A group of school children assembled and hugged a big tree in Union Square Park, followed by some adults.

4.4.2 Silent Valley Movement

Silent Valley occupies an area of 8950 hectares at an altitude of 3000 ft. in Palakkad district, Kerala. It is surrounded by the Nilgiri forests to the north and Attappadi forests to the east—together they comprise 40,000 hectares of pristine (i.e., primitive) forest. This tropical rain forest in the Western Ghats is a precious reservoir of genetic diversity which has not been fully exploited—here plant species and other forms of life have survived for centuries in the forest. It is this gene pool to which man has to turn in future for new materials for agriculture, for life-saving drugs, etc.

The Kerala State Government decided to construct a dam in the Silent Valley for generation of 120 MW (megawatts) of electricity in 1976 at an estimated 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. In order to save the Silent Valley from destruction in the process of government dam project, the Kerala-based NGO, Kerala Sastra Sahitya Parishad (KSSP) launched the Silent Valley Movement, supported by students, teachers and people of Kerala.

Soon the apex policy-making bodies NCEPC, DOEn and Switzerland-based IUCN (International Union for Conservation of Nature and Natural Resources) strongly supported the cause of Silent Valley. Finally the Prime Minister (Indira Gandhi) in 1983 accepted the recommendation of top scientists and environmentalists and declared the Silent Valley as the Biosphere Reserve by cancelling the hydel project proposal of the State government.

This is the success story of an environmental movement for protection of an important biosphere reserve.

4.4.3 Narmada Dam

Narmada is the largest west flowing river arising from the Amarkhandak plateau in Shahdol district of Madhya Pradesh and travels 1300 km, draining 9.88 million hectares between the Vindhya and Satpura ranges. This vast basin—average annual flow is 41 billion cubic metres—is mostly untapped because of inter-state (Gujarat, MP) water disputes. The MP government undertook a gigantic plan—Narmada Basin Development Programme—which involves construction of 31 large dams for Narmada and its tributaries, 450 medium-sized projects and several thousand minor structures at a cost of about Rs 25,000 crores. The benefits were projected—several million hectares of land irrigated; water supply to thousands of industries; several thousand megawatts of power, etc.

But according to environmentalists and environment action groups, massive damming of the Narmada river could be a blueprint for disaster. The basin is one of the most dense forests in India. The project would imply displacement of over 1 million people, mostly tribals, submerging of over 1000 villages and over 50,000 hectares of agricultural land and also loss of forests in the region. The damage to environment and people far outweighs the projected benefits. The environmental action groups, led by the environmentalist, Smt. Medha Patekar, organised sustained movement to stall the projects of Sardar Sarovar and Narmada Sagar dams and partly succeeded.

4.5 ENVIRONMENTAL ETHICS AND AWARENESS

India has a rich tradition of environmental ethics since the Vedic era, some 5000 years ago. The spirit of conservation ethics was inherent in our history, culture, religion and philosophy. The message of *Isha-Upanishad* underscores the philosophy:

> "The Universe has been created and nurtured by God. Man can enjoy the bounties of Nature by giving up greed."

The sublime concept of living harmoniously with nature was practised by our *rishis* (seers); their *tapovan ashramas* (forest hermitages for meditation) and *gurukul education* (teacher-based education) are models for all ages. The compassion for animates and inanimates is the keynote of Indian culture. Buddha and Mahavira preached *non-violence* ("Ahimsa Paramo Dharma") 2500 years ago, which was also introduced in the 20th century by Mahatma Gandhi. The Nobel laureate world poet, Tagore presented to the nation the concepts and practices of Vriksharopana (tree plantation) ceremony in 1927 and Ashrama Model Open Air School at Santiniketan (1902), that is, long before the world woke up to the alarming environmental issues.

But we failed to sustain our heritage of environmental ethics and lead the world in this matter. We were swept by the western world approach of establishing supremacy over nature and exploiting the natural resources, instead of utilising them as per our old tradition. Again our concern for environment started only two decades after the western world took note of it and worked seriously for handling the environmental issues.

4.5.1 Environmental Awareness

The International Conference on Environmental Education in 1981 stressed the need for environmental education at all levels to help arouse social and community consciousness about the environment.

The **Bhopal disaster** of 1984, the worst environmental disaster in history, focussed very bluntly on the need of environmental education and awareness in India. The disaster took toll of 10,000 lives in one week; 1000 people

turned blind and more than 1 lakh people continue to suffer from various disorders. This tragedy was possible in Third World countries like India due to negligence and lack of awareness at all levels—Central government, State government, industry, public and hospital doctors.

In this context, it is important to note the Chinese proverb relating to education:

> **"If you plan for one year, plant rice;**
> **If you plan for ten years, plant trees;**
> **But if you plan for 100 years, educate the people."**

So, people's education is important in the long-term interest of a country.

People must be made aware of the present state of environment and crisis and also the remedies. Both formal and non-formal education should be the instruments of education and awareness. Formal education (school/college/university) is meant for students in the educational system. Non-formal education (adult education, literacy mission, etc.) is meant for those who are outside our educational institutions, that is, the majority of Indian population. In other words, the basic or elementary concepts of environment should reach out to the entire population all over the country. The University Grants Commission recently urged the universities to introduce the syllabus on environment for undergraduates in all streams (Arts/Science/Commerce). The present book has been designed as a textbook for this purpose.

Environmental ethics can be cultivated from now on so that it can be part of the lifestyle of the present and future generations. The following guidelines are meant for the government/institutions and individuals in their daily lives:

For the Government(National Policy)[Action Plan]

1. Reduce population growth rate by 30 per cent (from 3.0 to less than 2.0 per cent) over the next five years.

2. Reduce livestock population by 30 per cent over the next five years in order to cut down methane (green house gas) emissions.
3. Shift from coal-fired thermal power stations to gas-fired power stations, solar energy, wind power and hydel power as alternative sources of energy.
4. Impose heavy penalties for motor vehicles exceeding emission levels.
5. Introduce CFC-substitutes in all air-conditioners and refrigerators to reduce ozone hole.

For the Individuals and Groups [Actions Plan]

1. Keep your home, the surrounding areas and also working places (offices/institutions) clean.
2. Enforce "No Smoking" in as many public places (offices/institutions/banks/post offices/public transports/public halls, etc.) as possible besides own homes.
3. Promote literacy and environmental campaigns among the masses.
4. Organise environmental brigades in every block consisting of young and old people including girls and women for protection and conservation of environment.
5. In critical situations where environment is on the point being destroyed, organise environmental movement along the lines of the Chipko and Silent Valley movements involving teachers, students and people.
6. Let us take the solemn pledge in our day-to-day life that we shall do our best to make this world a better place to live in for our next and future generations.

4.5.2 Non-Government Organisations (NGOs)

NGOs play important roles in environmental awareness and education. Out of about 200 NGOs, 130 are engaged in

these areas, 50 in nature conservation, 50 in pollution control, 45 in afforestation and social forestry, 15 in rural development and 10 in eco-development. Most of these carry out academically-oriented activities. In critical situations, they also launch environmental movements. Among the pioneer NGOs, mention should be made of Kerala Sastra Sahitya Parishad (KSSP) which piloted the Silent Valley Movement and successfully stalled the State government hydel project.

Questions

1. Give a brief account of the environmental policies of the government of India relating to (i) forests, and (ii) biosphere.
2. State the environmental laws relating to
   (i) Water
   (ii) Air
   (iii) Wildlife.
3. Explain the importance of Environmental Impact Assessment (EIA) for development projects.
4. Give notes on:
   (a) Chipko Movement
   (b) Silent Valley Movement
5. Elucidate: "India has rich heritage in environmental ethics but failed to lead the world in this area."

FEEDBACK EXERCISE (OBJECTIVE TEST)

Put a tick mark (√) against the correct answer/answers in the boxes given. There may be more than one correct answers—they should be marked. *This feedback exercise will help the students to test their understanding of the subject matter of this book which in turn will sustain their interest in environmental science.*

1. Environment means

(a) a beautiful landscape ☐
(b) industrial production ☐
(c) sum total of all conditions that affect the life and development of all organisms on earth ☐

2. Environmental studies involve studies of

(a) evolution of life ☐
(b) all aspects of human environment ☐
(c) nitrogen cycle ☐

3. The killer in Bhopal Disaster was

(a) methyl isocyanate ☐
(b) carbaryl ☐
(c) accidental fire in the factory ☐

4. The quality of environment has steadily suffered due to

(a) man-made activities ☐
(b) air, water, soil and food pollution ☐
(c) public awareness ☐

5. Environmental degradation has been due to

(a) poverty of the developing countries ☐
(b) over-consumption of earth's resources by the developed countries ☐
(c) poor quality of life ☐

6. The earth was born

(a) 6.0 billion years ago ☐
(b) 4.5 billion years ago ☐
(c) 10,000 years ago ☐

7. The first living form (blue-green algae) appeared on earth

(a) 3.5 billion years ago ☐
(b) 6.0 billion years ago ☐
(c) 5.0 billion years ago ☐

8. Soil has an important role as it

(a) gives us space for building houses ☐
(b) produces food for us and animals ☐
(c) provides highways for traffic ☐

9. Soil, suitable for agriculture, consists of

(a) micro-organisms only ☐
(b) rock powder and water ☐
(c) 5 per cent organic and 95 per cent inorganic matter ☐

10. Biosphere means

(a) the earth's crust only ☐
(b) the earth's crust, air, water and all living species ☐
(c) micro-organisms only ☐

11. The earth swings back and forth between hot and cold periods

(a) with the rise and fall of carbon dioxide concentration ☐
(b) with change in ocean currents ☐
(c) with increased deforestation ☐

12. We get our supply and reserves of freshwater

(a) from hydrological cycle ☐
(b) from carbon cycle ☐
(c) from snowfall ☐

13. The source of atmospheric oxygen is

(a) the nitrogen cycle ☐
(b) photosynthesis by green plants ☐
(c) exchange of oxygen among the environmental segments ☐

14. The major reservoir of carbon (carbon dioxide) is

(a) the ocean beds ☐
(b) the atmosphere ☐
(c) plants and animals ☐

15. Forests are important

(a) for life-support systems ☐
(b) renewable resources ☐
(c) for animals only ☐

16. India has been losing

(a) very little forests each year ☐
(b) 1.3 million hectares of forests each year ☐
(c) 100 million hectares of forests each year ☐

17. The main causes for deforestation are

(a) tribal people ☐
(b) increasing human and livestock population ☐
(c) timber business ☐

18. The aim of social forestry is to meet the demand for

(a) firewood and fodder among rural people ☐
(b) furniture for urban people ☐
(c) removing pressure on natural forests ☐

19. Biodiversity involves

(a) forests only ☐
(b) the living natural resources (plants, animals, micro-organisms) ☐
(c) human beings ☐

20. Extinction of species is

(a) part of natural extinction ☐
(b) natural extinction accelerated by man-made extinction ☐
(c) due to natural disasters ☐

21. The P-Triangle is composed of

(a) biodiversity ☐
(b) population, poverty and pollution ☐
(c) poverty, flood and drought ☐

22. Indian population doubled

(a) between 1901 and 1930 ☐
(b) between 1950 and 1981 ☐
(c) between 1941 and 1961 ☐

23. The countries with 1-billion + population are

(a) China and India ☐
(b) USA and Canada ☐
(c) France and Germany ☐

24. Population explosion occurs when

(a) population increases at a slow rate ☐
(b) population size exceeds the carrying capacity ☐
(c) population matches the natural resources ☐

25. Population stabilisation is essential for

(a) agriculture ☐
(b) economic growth ☐
(c) sustainable development ☐

26. Human Development Index (HDI) is based on the parameters

(a) life span, literacy and standard of living ☐
(b) growth of population and industry ☐
(c) income and education of an adult ☐

27. In India, 50 per cent population

(a) have good standard of living ☐
(b) live below the poverty line ☐
(c) have no access to safe drinking water ☐

28. India loses topsoil

(a) 5 billion tonnes a year ☐
(b) 1 billion tonnes a year ☐
(c) 25 billion tonnes a year ☐

29. Soil erosion or loss of topsoil is caused by

(a) agriculture ☐
(b) deforestation ☐
(c) drought and flood ☐

30. Freshwater available for our use is

(a) less than 5 per cent of total water resources ☐
(b) more than 10 per cent of total water resources ☐
(c) less than 1 per cent of total water resources ☐

31. Ocean water, vast water resource (97 per cent), is

(a) good for agriculture ☐
(b) unfit for human consumption ☐
(c) useful for coastal vegetation ☐

32. Compared to sea water and lake water, groundwater contains

(a) same mineral salts, nitrate, and bicarbonate ☐
(b) less mineral salts, nitrate and bicarbonate ☐
(c) more mineral salts, nitrate and bicarbonate ☐

33. The symptoms of polluted water are

(a) no change in physical appearance ☐
(b) no external matter on the surface ☐
(c) foul smell, bad taste, oil and grease and dead fish floating on the surface ☐

34. Organic pollutants in water include

(a) soap and detergents ☐
(b) mine drainage (acid) ☐
(c) domestic sewage, pesticides, paper mill and tannery wastes ☐

35. Eutrophication results from

(a) Agricultural run-off and domestic sewage input ☐
(b) industrial effluent ☐
(c) vehicular exhausts ☐

36. Pesticide residues in crops enter the human bodies through

(a) birds and insects ☐
(b) human food chain ☐
(c) animals only ☐

37. Thermal pollution originates from discharge of waste water from

(a) steel plant ☐
(b) nuclear power plant ☐
(c) thermal power plant ☐

38. Arsenic contamination of groundwater arises from

(a) excessive pumping of groundwater by shallow tube wells for irrigation ☐
(b) seepage of surface water ☐
(c) leaching of arsenopyrite mineral into groundwater ☐

39. Arsenic poisoning from drinking water leads to

(a) loss of hair, brittle nails, gangrene and cancer ☐
(b) diarrhoea, dysentery, etc. ☐
(c) pneumonia, typhoid, etc. ☐

40. The Ganga river is heavily polluted at

(a) Rishikesh and Haridwar ☐
(b) Kanpur, Varanasi and Kolkata ☐
(c) Patna and Allahabad ☐

41. The Ganga pollution is due to dumping of

(a) domestic and industrial sewage ☐
(b) waste from forests ☐
(c) food wastes ☐

42. The Ganga Action Plan is based on

(a) mixing with rainwater ☐
(b) preventing input of domestic and industrial wastes ☐
(c) recycling of water after waste treatment ☐

43. Primary and secondary wastes water treatment are based on

(a) screening of solid matter only ☐
(b) injecting air stream only ☐
(c) screening, sedimentation, aerobic digestion and sedimentation ☐

44. The important water quality parameters are

(a) calcium, magnesium, iron ☐
(b) lead, zinc, mercury ☐
(c) dissolved oxygen, chemical oxygen demand, chloride and arsenic ☐

45. Desalination of sea water means

(a) removal of salts from sea water ☐
(b) dumping of oil into sea water ☐
(c) removal of suspended solids from sea water ☐

46. Water treatment for drinking water supply requires

(a) filtration through sand bed ☐
(b) disinfection by chlorination to kill viruses, bacteria, etc. ☐
(c) sedimentation ☐

47. The major components of the atmosphere are

(a) rare gases ☐
(b) carbon dioxide and argon ☐
(c) nitrogen, oxygen and water vapour ☐

48. The important chemical species in the troposphere are

(a) oxygen, nitric oxide ☐
(b) nitrogen, oxygen, carbon dioxide and water vapour ☐
(c) sulphur dioxide, carbon monoxide ☐

49. The life-saving gas in the atmosphere is

(a) ozone in the stratosphere ☐
(b) water vapour in the troposphere ☐
(c) oxygen (charged) in the mesosphere ☐

50. Global warming is a/an

(a) ocean phenomenon ☐
(b) atmospheric phenomenon ☐
(c) soil phenomenon ☐

51. The Greenhouse Effect is due to

(a) carbon dioxide, water vapour, methane and chlorofluorocarbons ☐
(b) nitrogen oxides ☐
(c) sulphur oxides ☐

52. The Greenhouse Effect may cause global disasters

(a) by favouring forest fires ☐
(b) by increasing the frequencies of cyclones ☐
(c) by affecting agricultural production, sea food production and raising the sea levels due to melting of polar ice caps ☐

53. The protective shield for life on earth is

(a) carbon dioxide ☐
(b) oxygen ☐
(c) ozone ☐

54. Ozone hole is formed by interaction of ozone with

(a) hydrocarbons ☐
(b) chlorofluorocarbons and nitric oxide ☐
(c) carbon dioxide ☐

55. El Nino starts from

(a) Mediterranean coast ☐
(b) Chinese coast ☐
(c) South American coast ☐

56. Automobile exhausts consist of

(a) hydrocarbons, carbon monoxide and nitric oxide ☐
(b) carbon, zinc and lead vapour ☐
(c) sulphur dioxide ☐

57. Autoemissions are controlled by

(a) using oxygen stream in the exhaust pipes of automobiles ☐
(b) using catalytic converters in the engines ☐
(c) replacing petrol/diesel by alcohol ☐

58. Photochemical smog arises from

(a) ozone and methane in the presence of sunlight ☐
(b) carbon monoxide and sulphur dioxide ☐
(c) photochemical reactions of hydrocarbons, ozone, carbon monoxide and nitrogen oxides ☐

59. Primary air pollutants are

(a) oxygen, nitrogen and water vapour ☐
(b) carbon monoxide, nitrogen oxides, sulphur oxides, hydrocarbons and particulates ☐
(c) carbon dioxide, sulphur dioxide and ozone ☐

60. Acid rain consists of

(a) acetic acid and phosphoric acid ☐
(b) acetic and sulphuric acids ☐
(c) hydrogen chloride, nitric and sulphuric acids ☐

61. Acid rain originates from

(a) steel plants ☐
(b) thermal power plants ☐
(c) nuclear reactors ☐

62. Fine particles (0.01–1.0μ size) cause

(a) asthma, bronchitis, tuberculosis ☐
(b) dysentery and diarrhoea ☐
(c) typhoid ☐

63. The source of soot particles in air is

(a) burning of paper ☐
(b) combustion of fuel ☐
(c) evaporation of water from seas ☐

64. Particulate emissions from gas streams can be removed by

(a) lightning discharge in air ☐
(b) electrostatic precipitator ☐
(c) air jet ☐

65. Temperature inversion occurs when

(a) warm air moves above a cold air mass ☐
(b) there is rainfall ☐
(c) drought condition prevails ☐

66. Meteorology of the earth is affected by

(a) natural disasters ☐
(b) human activities ☐
(c) the earth's rotation ☐

67. Fossil fuel means

(a) hydroelectricity ☐
(b) coal, petroleum and diesel ☐
(c) paper and wood ☐

68. Conventional energy resources are

(a) solar energy ☐
(b) tidal wave energy ☐
(c) fossil fuel, wood, natural gas, hydroelectricity and nuclear energy ☐

69. The most abundant energy resource is

(a) coal ☐
(b) solar energy ☐
(c) diesel ☐

70. Nuclear power is produced from

(a) petroleum combustion ☐
(b) wood combustion ☐
(c) nuclear fission ☐

71. The major renewable natural energy resource is

(a) coal ☐
(b) wood ☐
(c) nuclear fuel ☐

72. Sunlight may be converted into electricity through

(a) photovoltaic cell ☐
(b) galvanic cell ☐
(c) carbon electrodes ☐

73. Solar energy-based equipments are

(a) diesel engine ☐
(b) solar cooker, solar heater, solar pump, etc. ☐
(c) tube well pump ☐

74. The clean pollution-free energy resource is

(a) petroleum and diesel ☐
(b) coal ☐
(c) solar energy ☐

75. Hazardous chemicals cause

(a) no harm to human bodies ☐
(b) little harm to animals ☐
(c) metabolic disorders in human bodies ☐

76. Industries producing toxic wastes are

(a) pharmaceuticals ☐
(b) fertilisers ☐
(c) pesticides ☐

77. Arsenic

(a) does not affect our health ☐
(b) damages liver, kidney, skin, etc. ☐
(c) attacks teeth and nails of humans ☐

78. Cadmium is

(a) beneficial for our health ☐
(b) responsible for "itai itai" disease ☐
(c) without effect on plants ☐

79. Chlorinated organics (pesticides)

(a) eradicate malaria ☐
(b) are carcinogenic ☐
(c) harmful for crops ☐

80. The heavy metal, mercury is

(a) useful, in traces, in medical treatment ☐
(b) a killer in its methyl form and responsible for Minamata diseases ☐
(c) useless for industries ☐

81. Phosphatic fertiliser factories generate byproduct wastes

(a) ammonium sulphate ☐
(b) phosphogypsum ☐
(c) potassium sulphate ☐

82. Thermal power plants produce solid wastes

(a) sulphur dioxide ☐
(b) calcium phosphate ☐
(c) flyash ☐

83. Pesticides are used to

(a) favour growth of insects ☐
(b) reduce production of crops ☐
(c) kill pests and boost agricultural production ☐

84. Pesticide residues

(a) have no effect on environment ☐
(b) cause harm to birds, mammals and humans ☐
(c) are maximum among Indians ☐

85. Integrated Pest Management (IPM) in agriculture means

(a) control of pest population ☐
(b) eradication of pests ☐
(c) co-ordination of methods supplementing the effects of natural control agents ☐

86. Arsenic (III) exerts toxic action by

(a) attacking –OH (hydroxyl group) of an enzyme ☐

(b) attacking –SH (sulphydril group) of an enzyme ☐
(c) reaction with $-NH_2$ (amino group) of protein ☐

87. "Itai itai" disease was caused by

(a) zinc ☐
(b) cadmium ☐
(c) mercury ☐

88. Minamata disease in Japan was due to

(a) alkyl form of mercury ☐
(b) cadmium sulphate ☐
(c) lead chromate ☐

89. Mercury pollution can be prevented by

(a) banning use of mercury in any form in industries ☐
(b) banning all instruments using mercury such as thermometer, barometer, etc. ☐
(c) restricting use of mercurial pesticides and mercury electrodes in industries ☐

90. Noise pollution occurs at

(a) 20 decibels ☐
(b) above 90 decibels ☐
(c) above 150 decibels ☐

91. Solid waste management is best conducted by

(a) incineration ☐
(b) dumping into the seas ☐
(c) sanitary landfill ☐

92. Love Canal dumpsite

(a) did not harm the school and local residents ☐
(b) compelled the authorities to close the school and evacuate the residents in the area ☐
(c) favoured the growth of vegetation in the area ☐

93. The ideal forest cover in relation to total land area is

(a) 55 %
(b) 33 %
(c) 80 %

94. Biosphere reserves have been declared by the Government for conservation of

(a) waterbodies
(b) air
(c) the different ecosystems

95. Environment Protection Act of 1986 is meant for

(a) waste management
(b) protection of human environment including humans, plants, animals and property
(c) forest management

96. Chipko Movement was launched for

(a) stopping deforestation of hill forests in Uttarakhand
(b) land protection
(c) wild-life management

97. Silent Valley Movement succeeded in

(a) waste management in the sea coast
(b) cancelling the state government hydel project and saving the Silent Valley
(c) promoting marine fishery business in Kerala

98. Continental drifting is

(a) due to motion of landmass
(b) due to earthquakes
(c) due to formation of mountains

99. Earthquakes are caused by

(a) violent storms
(b) collision of tectonic plates
(c) volcanic explosion

100. Minamata disease occurred

(a) as a result of oil pollution ☐
(b) as a result of zinc discharge ☐
(c) due to mercury poisoning ☐

101. Bhopal disaster was due to

(a) methyl isocyanate leakage ☐
(b) steam discharge ☐
(c) negligence of factory authorities ☐

102. Chernobyl disaster happened

(a) because of nuclear reactor explosion ☐
(b) due to flyash emission ☐
(c) due to power plant failure ☐

103. Big Bang was a cosmic event

(a) some 1-billion years ago ☐
(b) some 2-billion years ago ☐
(c) some 6.5-billion years ago ☐

104. Biome is

(a) large land community with uniform plant species ☐
(b) marine ecosystem ☐
(c) tropical forest ☐

105. Wetland ecosystem is

(a) combined land and aquatic ecosystem ☐
(b) ponds and lakes ☐
(c) tropical forest ☐

106. Urbanisation means

(a) transformation of villages ☐
(b) construction of cities with infrastructure ☐
(c) migration of landless people ☐

107. Lithosphere means

(a) earth's interior core ☐
(b) earth's crust ☐
(c) underground water layer ☐

108. Geologic cycle denotes

(a) recycling of earth's crust ☐
(b) weathering of soil ☐
(c) eruption of volcanic lava ☐

109. Biogeochemical cycles are

(a) same as hydrological cycle ☐
(b) similar to geological cycle ☐
(c) circulation of chemical elements among biological organism and physical environment ☐

110. Tornadoes are

(a) storms and rains ☐
(b) violent thunderstorms ☐
(c) thunder, lightning and rain ☐

111. Mangroves are

(a) desert plants ☐
(b) high-altitude plants ☐
(c) forests in tidal zones of equatorial and tropical coasts ☐

112. Sustainable ecosystem consists of

(a) land, forest and water ecosystem which can be renewed ☐
(b) tropical forests ☐
(c) coastal lakes and forests ☐

113. Carrying capacity means

(a) ability to carry the burden of goods ☐
(b) maximum population that can be sustained by an ecosystem ☐
(c) capacity to hold an ecosystem ☐

114. Population density is

(a) population size of a country ☐
(b) number of people per sq. km of an area ☐
(c) population growth per year ☐

115. Watershed is defined as

(a) a water course ☐
(b) drainage basin of a water course of a river or stream enclosed by hills ☐
(c) waterfalls ☐

116. Greenhouse gases are

(a) carbon monoxide and sulphur dioxide ☐
(b) carbon dioxide, methane, ozone ☐
(c) chloroform, ether ☐

117. El Nino is

(a) atmospheric phenomenon ☐
(b) volcanic activity ☐
(c) ocean warming phenomenon ☐

118. Odour pollution arises from

(a) garbage heap, sewage water, etc. ☐
(b) flowery plants ☐
(c) public urinals and toilets ☐

119. Hydroelectricity is generated from

(a) lakes and ponds ☐
(b) water reservoir of river dam ☐
(c) coal plants ☐

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SAMPLE QUESTION PAPERS

SAMPLE PAPER–I
SCIENCE STREAMS

The figures in the margin indicate full marks

1. Answer any twelve questions of the following giving (√) mark in appropriate box: ***2 × 12***

1.1 Non-living components of ecosystem are

(a) Biotic ☐
(b) Abiotic ☐
(c) Free living ☐
(d) None ☐

1.2 Acid rain is caused by the oxides of

(a) SO_2 ☐
(b) NO_2 ☐
(c) Both ☐

1.3 Converting solid waste into new products by using resources contained in the discarded material is

(a) Waste management ☐
(b) Reuse ☐
(c) Recycling ☐

1.4 Which amongst the following is decomposer in ecosystem?

(a) Green plant ☐
(b) Animal ☐
(c) Bacteria ☐
(d) (a) and (b) ☐

1.5 Acidity in rain is measured by

(a) Barometer ☐
(b) Hygrometer ☐
(c) Ammeter ☐
(d) pH meter ☐

1.6 The process by which anaerobic decomposition of organic matter by bacteria gives out a bad smell is

(a) Decomposition ☐
(b) Fermentation ☐
(c) Putrefaction ☐

1.7 Profuse growth of aquatic vegetation that often changes the colour of water and reduces the dissolved oxygen content is called

(a) Algal bloom ☐
(b) Eutrophication ☐
(c) Fermentation ☐
(d) (a) and (b)

1.8 Montreal Protocol signed in September 1987 aims at the control of

(a) Use of ozone-depleting substances ☐
(b) Use of greenhouse gases ☐
(c) Use of chemical pesticides ☐

1.9 Stone cancer or stone leprosy is caused by

(a) UV rays ☐
(b) Greenhouse effect ☐
(c) Acid rain ☐
(d) Ozone depletion ☐

1.10 Tree hugging movement is

(a) Chipko Andolan ☐
(b) Green movement ☐
(c) Silent Valley movement ☐

1.11 Rio declaration refers to

(a) Earth Summit in June 1992 ☐
(b) Ramsar Conference ☐
(c) Stockholm Conference 1972 ☐

1.12 World Environment Day is observed on

(a) April 22 ☐
(b) June 22 ☐
(c) June 5 ☐

1.13 Ozone layer depletion occurs in

(a) Stratosphere ☐
(b) Troposphere ☐
(c) Ionosphere ☐

1.14 Global warming is caused by

(a) Acid rain ☐
(b) Ozone depletion ☐
(c) Greenhouse gases ☐

1.15 The source of oxygen in atmosphere is due to

(a) Respiration ☐
(b) Excretion ☐
(c) Photosynthesis ☐

1.16 The scale that measures the magnitude of earthquake is

(a) Kelvin scale ☐
(b) Fahrenheit scale ☐
(c) Richter scale ☐

1.17 At the time of formation of earth, free oxygen in atmosphere was

(a) Available ☐
(b) Not available ☐

1.18 CFC is

(a) Chlorofluorocarbon ☐
(b) Centre for fuel control ☐
(c) Carcinogenic fluoride compound ☐

1.19 Which amongst the following is primary consumer?

(a) Bacteria ☐
(b) Tiger ☐
(c) Goat ☐
(d) Vulture ☐

1.20 Of the following, water-borne disease is

(a) Small pox ☐
(b) Cholera ☐
(c) Diabetes ☐

2. Answer only ten questions (within 2–3 lines) 2 × 10

2.1 Define atmosphere.
2.2 What are the renewable and non-renewable energy sources? Give one example for each.
2.3 Name the principal gases of atmosphere.
2.4 State the importance of mangrove forest.
2.5 Define a producer (in ecology) giving an example.
2.6 What is wildlife sanctuary?
2.7 Describe two major air pollutants emitted by automobiles.
2.8 What is BOD?
2.9 What is biomass?
2.10 What is wetland? Name two important wetlands in India.
2.11 Name three sources of odour pollution.

2.12 What is the permissible noise level at night as prescribed by the Central Pollution Control Board in (i) residential areas and (ii) in silent zones?

2.13 Define biogeochemical cycle.

2.14 State the impact of land degradation on agriculture.

2.15 What is carrying capacity of environment?

2.16 What is Green Bench?

2.17 What is Agenda 21?

2.18 Explain what is biomagnification.

2.19 Explain what is composting.

2.20 Name two Project Tiger Reserves in West Bengal.

3. Answer any one question (with in 120 words) 6 × 1

3.1 Explain what is biodiversity and the necessity for its preservation.

3.2 Name two non-conventional energy sources and mention their possible applications in the Indian context.

3.3 Give an outline of natural and man-made disasters.

3.4 What are the measures to be taken to prevent water pollution-related diseases?

3.5 What is nitrogen cycle? State the role of bacteria in nitrogen cycle.

3.6 State the importance of wetland.

SAMPLE PAPER–II

ARTS AND COMMERCE STREAMS

The figures in the margin indicate full marks

1. Answer only twelve questions putting (√) marks in appropriate box: ***2 × 12***

1.1 The earliest traces of life on earth have been found in the rocks of

(a) 3.5-trillion years old ☐
(b) 3.5-billion years old ☐
(c) 3.5-million years old ☐

1.2 Richter scale is used for measuring

(a) Velocity of light ☐
(b) Intensity of sound ☐
(c) Amplitude of seismic waves ☐

1.3 Bhopal gas disaster occurred in

(a) 1964 ☐
(b) 1974 ☐
(c) 1984 ☐

1.4 In 1986, nuclear plant disaster took place in

(a) London ☐
(b) Chernobyl ☐
(c) Three Miles ☐

1.5 First UN Conference on Environment was held in

(a) Johannesburg ☐
(b) Stockholm ☐
(c) Montreal ☐

1.6 Which one of the following gases is most abundant in atmosphere?

(a) Methane ☐
(b) Nitrogen ☐
(c) CFC ☐

1.7 The interior-most layer of the earth is known as

(a) Core ☐
(b) Crust ☐
(c) Mantle ☐

1.8 The landmass of the earth is known as

(a) Biosphere ☐
(b) Lithosphere ☐
(c) Stratosphere ☐

1.9 Mangroves are found in

(a) Pushkar lake ☐
(b) Sunderbans ☐
(c) Loktak lake ☐

1.10 Which one of the following is a pollution-free renewable resource?

(a) Fossil fuel ☐
(b) Solar energy ☐
(c) Wood ☐

1.11 What is the name of the supercontinent which broke into the present day continents?

(a) Pampas ☐
(b) Palaearctic ☐
(c) Pangaea ☐

1.12 Ozone hole is present in

(a) Biosphere ☐
(b) Troposphere ☐
(c) Stratosphere ☐

1.13 Which one of the following is an autotroph?

(a) Green plant ☐
(b) Fungus ☐
(c) Fish ☐

1.14 Human malaria is transmitted by

(a) *Anopheles* male ☐
(b) *Anopheles* female ☐
(c) *Culex* male ☐

1.15 The safe intensity level of sound is

(a) 85 decibel ☐
(b) 75 decibel ☐
(c) 65 decibel ☐

1.16 Silent Valley is in

(a) Andhra Pradesh ☐
(b) Himachal Pradesh ☐
(c) Kerala ☐

1.17 Which one of the following is not a gaseous cycle?

(a) Oxygen cycle ☐
(b) Phosphorus cycle ☐
(c) Nitrogen cycle ☐

1.18 Which one of the countries is known as the land of monsoon?

(a) Russia ☐
(b) India ☐
(c) Australia ☐

1.19 The earth receives major energy from

(a) Sun ☐
(b) Moon ☐
(c) Mars ☐

1.20 Which one of the following does not contain biomass?

(a) Municipal garbage ☐
(b) Sewage ☐
(c) Metal ☐

2. Answer only ten questions (within 2–3 lines): 2 × 10

2.1 What is meant by environmental studies?
2.2 What is succession?
2.3 Define wetland.
2.4 State the function of decomposers in an ecosystem.
2.5 What is biomagnification?
2.6 What is ecosystem?
2.7 Mention the major causes of air pollution in the urban areas.
2.8 What is biogas?
2.9 Define sustainable development.
2.10 State the importance of ozone layer.
2.11 What is Green Bench?
2.12 State the role of bacteria in nitrogen cycle.
2.13 What is meant by non-conventional energy?
2.14 What is exponential growth of population?
2.15 What is flyash?
2.16 Define carrying capacity.
2.17 What is aquifer?
2.18 Define aerosol.
2.19 What is EIA?
2.20 What is geothermal energy?

3. Answer any one question (within 120 words): 6 × 1

3.1 Briefly mention the role of biotic components of an ecosystem.
3.2 State the ecological and economical importance of biodiversity.
3.3 Briefly explain hydrological cycle.
3.4 State how population growth and natural resources are related.
3.5 Explain Gaia hypothesis.
3.6 Give an outline of environmental ethics.

4. Answer any twelve questions of the following giving (√) marks in appropriate box: 2 × 12

4.1 Seismograph is used for the measurement of

(a) Earthquake ☐
(b) Intensity of light ☐
(c) Humidity ☐

4.2 Jaldapara is famous for the conservation of

(a) Tiger ☐
(b) Rhinoceros ☐
(c) Elephant ☐

4.3 Earth Day is celebrated on

(a) 5th June ☐
(b) 12th May ☐
(c) 22nd April ☐

4.4 The mean temperature of Earth is approximately

(a) 10°C ☐
(b) 15°C ☐
(c) 20°C ☐

4.5 Cholera is a

(a) Vector-borne disease ☐
(b) Water-borne disease ☐
(c) Air-borne disease ☐

4.6 India is a megadiversity country with

(a) 4 ecological hotspots ☐
(b) 3 ecological hotspots ☐
(c) 2 ecological hotspots ☐

4.7 The permissible upper limit of Arsenic in water is

(a) 0.05 mg per litre ☐
(b) 0.005 mg per litre ☐
(c) 0.5 mg per litre ☐

4.8 An ecological thinking in which no particular importance is given to man

(a) Social ecology ☐
(b) Human ecology ☐
(c) Deep ecology ☐

4.9 The novel 'Aronnyok' is written by

(a) Rabindra Nath Tagore ☐
(b) Bibhutibhusan Bandopadhyay ☐
(c) Jibanananda Das ☐

4.10 The historic Earth Summit held at Rio, Brazil in June 1992 is known as

(a) UNCED ☐
(b) UNIDO ☐
(c) UNESCO ☐

4.11 Ramsar Convention includes one of the following

(a) Rabindra Sarovar ☐
(b) Subhas Sarovar ☐
(c) East Kolkata wetland ☐

4.12 The lowest layer of atmosphere

(a) Ionosphere ☐
(b) Troposphere ☐
(c) Stratosphere ☐

4.13 Bhopal gas disaster caused by the gas is

(a) Carbon monoxide ☐
(b) Chlorofluorocarbon ☐
(c) Methyl isocyanate ☐

4.14 'Arabari Model' in West Bengal is famous for

(a) Joint Forest Management ☐
(b) Rainwater Harvesting ☐
(c) Solar Power Plant ☐

4.15 The global human population is around

(a) 480 crores ☐

(b) 620 crores ☐
(c) 760 crores ☐

4.16 The name of Sundarlal Bahuguna is related to

(a) Chipko Movement ☐
(b) Narmada Bachao ☐
(c) Silent Valley ☐

4.17 The famous 3P formula on environment is

(a) Power-Production-Price ☐
(b) Population-Poverty-Pollution ☐
(c) Principle of Population Problem ☐

4.18 On earth, the autotrophic components can directly fix

(a) Chemical energy ☐
(b) Mechanical energy ☐
(c) Light energy ☐

4.19 The unit of dose of ionising radiation is

(a) ROM ☐
(b) RAD ☐
(c) CAD ☐

4.20 B.O.D. determines the health of

(a) Soil ☐
(b) Air ☐
(c) Water ☐

5. Answer any ten questions (with 2–3 lines): 2 × 10

5.1 State two causes of landslide.
5.2 Name two nitrogen-fixing bacteria.
5.3 What is an inverted pyramid?
5.4 What is wasteland?
5.5 What is social forestry?
5.6 What is carrying capacity?
5.7 What is photochemical smog?

5.8 What is Decibel?
5.9 What is ozone hole?
5.10 What is urbranisation?
5.11 What is Chipko Movement?
5.12 What is bioremediation?
5.13 What is environmental ethics?
5.14 What is bio-diesel?
5.15 What is El-Nino?
5.16 What is plate tectonics?
5.17 What is quarantine?
5.18 What is biodiversity?
5.19 What is a cyclone?
5.20 What is acid rain?

6. Answer any one question (within 120 words) 6 × 1

6.1 Briefly state the air-pollution status of Kolkata city.
6.2 Describe the importance of land-use planning.
6.3 Briefly state your view about the riverlinking proposals in Indian context.
6.4 State the reasons of wildlife extinction.
6.5 State the impact of economic development on environment in India.
6.6 Discuss your view about the importance of water conservation in our country.

SAMPLE PAPER–III

SCIENCE STREAMS

The figures in the margin indicate full marks

1. *Answer any twelve questions of the following giving (√) marks in appropriate box:* **2 × 12**

1.1 Rachel Carson is the writer of the following book

(a) Biodiversity ☐
(b) Silent Spring ☐
(c) Silent Valley ☐

1.2 5th June is observed as:

(a) Earth Day ☐
(b) Environment Day ☐
(c) Biodiversity Day ☐

1.3 A chronic disease called 'Silicosis' involves:

(a) Heart ☐
(b) Lung ☐
(c) Liver ☐

1.4 A Bengali novel of forestry and environment is

(a) 'Rupashi Bangla' ☐
(b) 'Sabhyatar Sankat' ☐
(c) 'Aronnyok' ☐

1.5 Pollen can cause

(a) Typhoid ☐
(b) Malaria ☐
(c) Allergy ☐

1.6 Free-floating microscopic organisms are known as

(a) Nekton ☐
(b) Plankton ☐
(c) Periphyton ☐

1.7 What happened in India in 1984?

(a) Chipko Movement ☐
(b) Bhopal gas disaster ☐
(c) Narmada Bachao Andolan ☐

1.8 Lithosphere represents the earth's

(a) Water ☐
(b) Land ☐
(c) Life ☐

1.9 Chernobyl nuclear power disaster took place in

(a) 1984 ☐
(b) 1986 ☐
(c) 1988 ☐

1.10* Plasmodium vivax *can cause

(a) Filaria ☐
(b) Malaria ☐
(c) Dengue ☐

1.11 The name of Rabindra Nath Tagore is connected with

(a) Joint Forest Management ☐
(b) Vanamahotsava ☐
(c) Tree-hugging movement ☐

1.12 The physical space occupied by an organism is known as

(a) Niche ☐
(b) Habitat ☐
(c) Ecotone ☐

1.13 Earthquake is measured by

(a) Electroencephalograph ☐
(b) Seismograph ☐
(c) Barometer ☐

1.14 'Study of habitat' is known as

(a) Ecology ☐
(b) Entomology ☐
(c) Ethology ☐

1.15 Aggregation of organisms of different populations refers to

(a) Density ☐
(b) Diversity ☐
(c) Population ☐

1.16 Following is a primary consumer

(a) Green plant ☐
(b) Deer ☐
(c) Tiger ☐

1.17 Biological control refers to

(a) Control of an organism by another organism ☐
(b) Control of an organism by using pesticide ☐
(c) Control of organism by themselves ☐

1.18 Earth is a

(a) Planet ☐
(b) Galaxy ☐
(c) Star ☐

1.19 'Agenda-21' refers to

(a) 1972 Stockholm Summit ☐
(b) 1992 Rio Summit ☐
(c) 2002 Johannesberg Summit ☐

1.20 Following is not found in natural condition in India

(a) Tiger ☐
(b) Zebra ☐
(c) Rhinoceros ☐

2. Answer any ten questions (within 2–3 lines): 2 × 10

2.1 What is a Biome?
2.2 What is Green belt?

2.3 What is Minamata disease?
2.4 What is Sanctuary?
2.5 What is Biofertilizer?
2.6 What is Metropolis?
2.7 What is IUCN?
2.8 What is Biological warfare?
2.9 What is organic farming?
2.10 What is Environmentalism?
2.11 What is endangered species?
2.12 What is dam?
2.13 What is waste?
2.14 What is afforestation?
2.15 What is soil-erosion?
2.16 What is Euro II (Bharat Stage II) in autoemission?
2.17 What is an 'Ecocity'?
2.18 What is E.I.A.?
2.19 Name four common water birds.
2.20 Name four common water pollutants.

3. Answer any one question (within 120 words) 6 × 1

3.1 Briefly state the environmental consciousness of Indian people.
3.2 Make comments on the implementation of environmental laws in India.
3.3 Briefly discuss the different components of a forest ecosystem.
3.4 What are the direct and indirect uses of Biodiversity?
3.5 Discuss the different alternative sources of energy.
3.6 Briefly state the importance of water conservation in our country.

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Appendices

Appendix–1. The Time Scale of Evolution

Time	*Event*
6.5–7.00-billion years ago	The Big Bang
4.50-billion years ago	The Earth was born
3.50-billion years ago	The blue-green algae (plant) was formed
3.00-billion years ago	The animal appeared
0.0025–0.0030-billion (25–30 lakh) years ago	The man appeared

Appendix–2. International si Units

The modern textbooks have adopted the System International (SI) units. However, these have not yet been accepted in toto. In this book, some SI units, universally adopted, have been used while the more familiar units, e.g., Å, atm, degree celsius, etc. are retained.

Physical quantity	*Name of unit*	*Symbol*
Length	metre	m
Mass	kilogram	kg
Amount of substance	mole	mol
Energy	joule	J
Temperature	kelvin (1°C = –273K)	K

1 calorie (thermochemical) = 4.184 J.

APPENDIX–3. DRINKING WATER QUALITY STANDARDS

In this Table, the permissible limits for water quality parameters, as laid down by the United States Public Health (USPH) Standard for drinking water and Indian Standards Institution (ISI), are listed for comparison. The ISI values, available for only a few parameters, are found to be much higher than those for USPH for no valid reasons. All the units, except for pH and *E. coli*, are in ppm or mg/ml.

Parameters	*USPH Standard*	*ISI Standard*
pH	6.0–8.5	6.0–9.0
Dissolved Oxygen (D.O.)	4.0–6.0	3.0
Chemical Oxygen Demand (COD)	4.0	—
Total dissolved solids	500	—
Suspended solid	5.0	—
Chloride	250	600
Sulphate	250	1000
Cyanide	0.05	—
Nitrate + Nitrite	< 10	—
Fluoride	1.5	3.0
Phosphate	0.1	—
Ammonia	0.5	—
Total hardness (as $CaCO_3$)	500	—
Calcium	100	—
Magnesium	30	—
Arsenic	0.05	0.2
Cadmium	0.01	—
Chromium (VI)	0.05	0.05
Iron (filterable)	< 0.3	—
Lead	0.05	0.01
Mercury	0.001	—
Zinc	5.5	—
Phenols	0.001	0.005
E. Coli (coliform cells)/1000 ml (Bacteriological parameter)	100	—

APPENDIX–4. TOXIC CHEMICALS IN THE ENVIRONMENT

There are a number of chemicals in the environment. Some of them are toxic while the rest are non-toxic. The toxic chemicals are discharged by the industries into air, water and soil. They enter our biological system through food chain and disturb the metabolic processes, leading in some cases to fatal results.

At present, there are four million known chemicals in the world and we are adding to the list 30,000 new compounds every year. Among these 60,000–70,000 chemicals are commonly used. Apart from their benefit to increasing production, living standards and health, many of them are potentially toxic.

Toxic Chemicals in Air

- Acrylonitrile, Arsenic, Asbestos
- Banzene, Beryllium
- Cadmium, Chromium, Chlorinated solvents, Coke oven emissions, Chlorofluorocarbons
- Ethylene dibromide, Ethylene oxide
- Lead, Mercury
- Ozone
- Polycyclic aromatic hydrocarbons
- Sulphur dioxide

Toxic Chemicals in Water

Trace Elements

- Arsenic
- Beryllium, Boron
- Cadmium, Chromium, Copper
- Fluoride
- Lead
- Manganese, Mercury, Molybdenum
- Selenium
- Zinc
- Pesticides (from agricultural run-off)

Appendix–5. The Haves and Have-nots (Developed and Developing Countries)

80:20 Ratio Twenty per cent of the world's population (developed countries) consume 80 per cent of the world's resources (natural), generate 75 per cent of total solid wastes and are responsible for 70 per cent of global environmental damage.

USA, with about half of India's population and double of India's area, discharges 5000 million tonnes of carbon dioxide every year—five times more than India.

Al Gore, Ex-Vice President of USA—UNEP magazine vol. 6, No. 2, 1994—The North (developed countries) accounts for overconsumption of resources while the South (developing countries) for population explosion and poverty.

Appendix–6. One Earth, One Family (Global Village)

The UNEP (United Nations Environment Programme) theme for 1994 was *One Earth, One Family*:

The Earth is not merely a "hotel"—it is our "home".

It is a place, where we should not use the resources and then move to another spot for further exploration.

— it is a place that we should cherish and need to protect.

It is not merely a "resource" or "retreat", which we use, enjoy and then leave.

— it is our **Mother**.

APPENDIX–7. INDIA'S RANK IN THE WORLD

Parameter	*Rank*
Population	2 (next to China)
Area	7
Value added in agriculture	5
Electricity generation	8
Value added in manufacturing	14
Gross Domestic Product	15
Export of goods and services	30
Human Development Index	128

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Glossary

Age-structure: Percentage of men and women in the young, adult and old age group in the population.

Acid Rain: Rain water containing mixtures of acids (nitric, hydrochloric and sulfuric acid) from polluted air is known as acid rain. It damages lakes, forests and marble sculptures.

Air Pollution: Various gaseous pollutants from natural and man-made source enter the atmosphere and have adverse effects on the normal properties of air. This leads to air pollution, which is harmful for man and environment.

Air Pollutants: Gases and particles which cause air pollution are called air pollutants.

Air Quality: Each pollutant in air has a limiting concentration, which if exceeded, causes public health hazards.

Aquifer: A highly permeable layer of sediment or rock containing water.

Anthropogenic: Caused by man or man-made things.

Bioaccumulation: Accumulation of non-biodegradable substances in the body (e.g., lead, mercury, DDT etc.) through food chain.

Biodiversity: Genetic variety among individual species and between species of plants, micro-organism and

animals. There are about 10 million species of plants, micro-organisms and animal on earth. These living natural resources are essential for the welfare of mankind.

Biogeochemical Cycles: Circulation of nutrients in cycles among air, soil, water and micro-organisms.

Biomagnification: Increase in concentration of non-biodegradable substance (e.g., lead, mercury, DDT) at successive trophic levels in a food chain (same as bioaccumulation above).

B.O.D.: Biological oxygen demand—amount of dissolved oxygen required by micro-organisms to breakdown organic matter present in water.

Biomass: Organise matter produced by living organisms.

Biome: A broad region-based ecosystem with distinct climate, soil, flora and fauna.

Biosphere: Composite environment consisting of land, air, water, micro-organism, plants, animals and man. Biosphere and environment have close interaction with each other.

Biosphere Reserve: World heritage sites, identified by ICECN, due to their high biodiversity and unique ecosystem e.g., Silent Valley (Kerala).

Carcinogen: Chemicals promoting cancer e.g., benzo-α-pyrene, arsenic, DDT etc.

Carrying Capacity: Maximum population size that a given system can support over a given period of time.

Chlorofluorocarbons (CFC): Used as solvent, refrigerant, fire retardant etc. Responsible for ozone hole and greenhouse effect.

Community: Population of various species living and interacting in a given area.

Compost: A nutrient rich soil produced by decomposition of organic matter under aerobic conditions.

DDT: Pesticide useful in agriculture and eradication of malaria.

Doubling Time: Period during which population doubles itself. It is about 100 years in developed countries and 40 years in India.

Dependency Ratio: Ratio of people 65 + (above 65) and 15 (under 15) to the rest of the population.

Ecology: Study of interactions of living organisms with their biotic and abiotic environments.

Ecosystem: A biological community and its physical environment exchanging matter and energy.

Environment: Something that environs i.e., encircles all our surroundings—the natural world in which we live — the living and non-living objects around us in our day-to-day living.

Environmental Studies: The studies of the quality of environment and all aspects of human environment, their degradation etc. comprise environmental studies.

Eutrophication: Overnourishment of waterbodies due to excessive nitrates and phosphates received through run-off—it is harmful for the waterbodies.

Environmental Impact Assessment (EIA): A systematic analysis of the effects of a major development project on environment.

Extinction: Loss of species on earth as natural or man-made process.

Fauna: All the animal species present in a given region.

Flora: All plant species present in a given region.

Food Chain: A feeding series in an ecosystem e.g. plants→animals→man.

Fossil Fuels: Fuels produced by fossilization of plants/ animals such as petroleum, coal, natural gas.

Gasohol: Mixture of gasoline and alcohol is known as gasohol, used as a fuel in Brazil for running cars and buses.

GNP (Gross National Product): An index of a country's economic status based on consumerism i.e., commodities purchased per year, consumer durables and financial status of consumer.

Greenhouse Effect (Global Warming): Rise in temperature of the earth's surface due to increase in the levels of greenhouse gases viz., carbon dioxide, methane etc. The latter trap heat from the earth's surface and returns it thereby raising the earth's surface temperature. This phenomenon is similar to trapping of heat in glass-covered green house (used for growth of vegetables and flowers during winter) and hence called greenhouse effect.

Greenhouse Gases: Gases such as carbon dioxide, methane, water vapour etc. which absorb earth's infra-red radiation, return it to the earth's surface thereby raising the temperature (global warming).

Groundwater: Water held in aquifers 50% below the earth's surface. This is the major source (0.66%) for freshwater.

Heterotroph: Organism that can't synthesize its own food and derives its nourishment by feeding on other.

Humus: A dark amorphous substance that is partially degraded and serves as a major source of nutrients to plants.

Hurricanes: Cyclonic storms with heavy rains and wind at speed exceeding 120 km/per hour.

Infant Mortality: Number of infants born per 1000 who die before their first birthday.

Life Expectancy: Average number of years a new-born baby is expected to survive.

Lithosphere: Outer shell of the earth's crust, made of the mantle of rocks. It includes the soil which covers the rock's crust in many places.

Magma: Molten rock below the earth's surface.

Monoculture: Cultivation of a single crop of tree.

Natural Gas: Underground deposits of gases containing mainly methane and small amounts of propane and butane. It is a cleaner fuel than fossil fuel as it produces less carbon dioxide on burning.

Natural Hazards: Hazards from natural sources (earthquake, volcanic eruption etc.) which destroy or damage human lives, houses etc.

Neutron: Nuclear particle with zero charge and mass, (relative to it).

Nitrogen Cycle: Continuous exchange of nitrogen within the ecosystem: air-soil-water.

Nitrogen Fixation: Conversion of atmospheric nitrogen gas into ammonia by nitrogen-fixing bacteria/cyanobacteria.

Nuclear Fission: Splitting of nucleus (uranium/plutonium) into two or more fragments with release of tremendous amount of energy. This is the source of nuclear power (electricity generation).

PAN (Peroxyacyl Nitrate): A toxic product of photochemical smog reactions.

Particulate Matter: Solid particles or ligand droplets suspended in air. Examples are smog particles from combustion of fossil fuels.

Photosynthesis: Synthesis of food (carbohydrates) by green plants in the presence of sunlight using carbon dioxide from air and water from soil.

Phytoplankton: Small plants like algae, bacteria found floating on the surface of water.

Photovoltaic Cell: Solar cell that converts, solar energy into electricity.

Population Explosion: Excessive growth of population as in developing countries, to a size that exceeds the carrying capacity.

Primary Pollutants: Gaseous and particulate pollutants discharged directly into the atmosphere by automobile exhaust

emissions. The gases thus discharged are carbon monoxide, nitrogen oxides, sulphur dioxide, and hydrocarbons.

Residence Time: Length of time for which a chemical or molecule stays in the environment. For example, the residence time of CFC (chlorofluorocarbon) molecule in the stratosphere is 100 years.

Sanitary Landfill: Waste disposal site on land in which solid waste is spread with fresh layer of clay.

Secondary Pollutant: Harmful pollutants generated from primary pollutants air, for example, sulphonic acid is a secondary pollutant, produced by the primary pollutant sulphur dioxide by reaction with water vapour in air.

Sustainable Development: Improvement in quality of life over a long-term without degrading the environment or compromising the needs of future generations.

Tectonic Plates: Huge blocks of earth's crust which slide along slowly.

Transpiration: Loss of water from plant surfaces.

Troposphere: The bottom region of the atmosphere at an altitude of 0-11 km. It contains 70 per cent of air masses which are always in motion. Here temperature decreases with increasing altitude.

Stratosphere: This region is above the troposphere at an altitude of 11-50 km above the earth's surface. Here ozone acts as a protective shield against ultraviolet radiation from space and thus protects life on earth.

Urbanization: Increasing population in cities by migration from villages and other states. India has a huge urban population (about 300 million).

Waterlogging: Saturation of soil with irrigation water or excessive rain whereby water table rises close to surface.

Watershed: Land area from which water drains under gravity to a common drainage channel.

Wetlands: Ecosystems with stagnant water pool and having rooted vegetation.