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B. Sc. (Part III) Chemistry-I

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U N I T

1

THE MULTIDISCIPLINARY NATURE OF ENVIRONMENTAL STUDIES

STRUCTURE

- Environment
- Mining and Its Effects
- Drought
- Food Resources
- Natural Resources
- Water Resources
- Dams
- Energy Resources
- Forest Resources
- Floods
- Mineral Resources
- Land Resources
- ❑ Summary
- ❑ Student Activity
- ❑ Test Yourself

LEARNING OBJECTIVES

After studying this chapter, you will learn about the environmental pollution, water, forest and natural resources etc., elementary idea about floods, drought, dams etc.

• 1.1. ENVIRONMENT

[I] Introduction

What does it mean when people say '*I am concerned about the environment*'? Environment is derived from the French words *environ* or *environner* meaning 'around', 'round about', 'to surround', these in turn orginated from the Old French *virer* and *viron* (together with the prefix *en*), which mean 'a circle, around, the country around or circuit'. Erymologists frequently conclude that, in English usage at least, environment is the *total of the things or circumstances around an organism-including humans—though environs is limited to the surrounding neighbourhood of a specifi c place, the neighbourhood or vicinity.*

Environmental study is only a recent phenomenon. After the Stockholm Conference (1972), people started giving serious thinking about the environmental problems. The *environment* can be protected by adopting the following rules :

(1) By balancing the ecosystem.
(2) By restricting and regulating the exploitation of natural resources.
(3) By maintaining the environmental quality.
(4) By adopting engineered technology without having adverse effects on the environment.
(5) By promoting environmental education among people.
(6) By controlling the population crisis and over-consumption of resources.
(7) By renovating, recycling and reusing the waste materials.
(8) By formulating strict laws and regulations to control pollution.

[II] Environmental Education

Environmental education (EE) is fast emerging as one of the most important disciplines in the world. The first seeds of environmental education were planted roughly a century ago and are found in the works of Marsh, Muir, Thoreau and Leopold. Their writings served to bring the world's attention to the depletion of *natural resources* and the often detrimental impact of humans on the environment. Nature education expanded the teaching of biology, botany and other natural sciences out into the natural world, where students learned through direct observation. Teacher training programmes were developed to meet the increasing demand. The *Conservation Education Association* found to consolidate these efforts and help solidify citizen support for natural resource management goals. The third pillar of modern EE

is outdoor education which refers more to the method of teaching than to the subject taught. The idea is to hold class-rooms outdoors, the topics are not restricted to only environmental issues but include art, music and other subjects. The EE programmes should be incorporated in all public school curricula.

[III] Definition of Environmental Education

What EE means depends on one's perspective. Some say that it is teaching method or philosophy to be applied to all subjects woven into the teaching of history, political science, economics etc. EE is also defined as, ***education process dealing with peoples relationships and their natural and manmade surroundings and includes the relation of population, pollution, resource allocation and depletion, conservation, transportation, technology and rural and urban planning to the total human environment.***

Each citizen of the country should be well educated with EE and should understand the environmental issues of his or her own community land use planning, traffic congestion, economic development plans, pesticide use, water pollution and air pollution and so on. In 1972, at the **United Nations Conference on the Human Environment** in Stockholm, the need for an international EE effort was clearly recognized and emphasized. Three years later, an **International Environmental Education Workshop** was held in Belgrade, from which emerged an eloquent, urgent, mandate for the drastic recording of national and international development policies. The '**Belgrade Charter**' called for an end to the military arms race and a new global ethic in which 'no nation should grow or develop at the expense of another nation'. It called for the eradication of hunger, illiteracy, poverty, pollution, domination and exploitation.

[IV] Effectiveness of Environmental Education

Environmental educators have formulated a basic framework for how to improve EE :

(a) Reinforce individuals for positive environmental behaviour over an extended period of time.

(b) Provide students with positive, informal experiences outdoors to increase their environmental sensitivity.

(c) Focus instruction on the concepts of ownership and empowerment. Ownership means that the learner has some personal interest in the environmental issues being discussed. Perhaps the student can relate more readily to concepts of solid waste disposal if there is a landfill in the neighbourhood. Empowerment gives learners the sense that they can make changes and help resolve environmental problems.

(d) Design an exercise in which students thoroughly study an environmental issue and then develop a plan for citizen action to address the issue, complete with an analysis of the social, cultural and ecological consequences of the action.

[V] Environmental Enforcement

Environmental enforcement is the set of actions that a government takes to achieve full implementation of environmental requirements within the regulated community and to halt or correct situations or activities that endanger the environment or public health. Enforcement by the government usually includes inspections to determine the compliance status of the regulated community and to detect violations, negotiations, with individuals or facility managers who are out of compliance to develop mutually agreeable schedules and approaches for achievement of compliance, legal action when necessary to compel compliance and to impose penalties.

Non-governmental organisations (NGO's) may become involved in enforcement by detecting non-compliance, negotiating with violators and commenting on governmental enforcement actions. They may also, as per the law, take legal actions against a violator for noncompliance or against the government for not enforcing environmental requirements.

Environmental enforcement is based on environmental laws. An environmental law provides the vision, scope and authority for environmental protection and restoration. Some environmental laws contain requirements, while others specify a structure and criteria for

establishing requirements which are then developed separately. Dissemination of information and product or use basis are also governed by environmental enforcement programmes. Information standards require a source of potential pollution to develop and submit information to the government. For example, a source producing pollution may be required to monitor, maintain records and report on the level of pollution generated and whether or not the source exceeds performance standards.

Environmental enforcement must include processes to balance the rights of individuals with the government's need to act quickly. A notice of violation should be issued before any action is taken so that the finding of violation can be contested or so that the violation can be corrected before further government action. Appeals should be allowed at several stages of the enforcement process so that the finding of violation, the required remedial action or the severity of the proposed sanction can be reviewed. There should also be dispute resolution processes for negotiations between programme officials and the violator which may include face-to-face discussions, presentations before a judge or hearing examiner or use of third party mediators, arbitrators or facilitators.

[VI] Environmental Policy

Strictly, an environmental policy can be defined as a *government's chosen course of action or plan to address issues such as pollution, wildlife protection, land use, energy production and use, waste generation and waste disposal.* Broadly, we may characterise a government's environmental policy by examining the overall orientation of its responses to environmental challenges as they occur or by defining its policy as the sum of plans for, and reactions to, environmental issues made by any number of different arms of government.

• 1.2. NATURAL RESOURCES

[I] Introduction

Natural resources, unlike man-made resources, exist independently of human labour. Natural resources are forests, wetland, wild life, mangroves etc. These are viewed as an endowment or a gift to humankind. These resources are, however, not unlimited and must be used with care. Some natural resources are called *fund resources* because they can be exhausted through use, like the burning of fossil fuels. Other fund resources such as metals can be dissipated or wasted if they are discarded instead of being reused or recycled. Some natural resources can be used up like fund resources, but they can renew themselves if they are not completely destroyed. Examples of the latter include soil, forests and fisheries. Because of population growth and a rising standard of living, the demand for natural resources is steadily increasing. For example, the rising demand for minerals, if continued, will deplete the known and expected reserves within the coming decades.

[II] Perpetual, Renewable and Non-Renewable Resources

The earth's resources are commonly divided into perpetual, renewable and *non-renewable resources.*

(1) Perpetual resources : Perpetual resources are those that are not affected by human use such as *solar energy* or *wind energy.*

(2) Renewable resources : On the contrary, renewable resources are all organic and inorganic meterials that are replenished by physical and biogeochemical cycles. Examples of organic renewable resources are *all plant* and *animal species that people use for food, building materials, drugs, leisure* and so on. Examples of inorganic renewable resources are *water* and *oxygen*, which are replenished in the hydrological and oxygen cycles, respectively. Renewable resources are sometimes called '*flow resources*', as their availability or sustainable yield actually depends on the rate of flow or the replacement rate instead of total volume.

(3) Non-renewable resources : Those materials that are present in the earth in limited amounts (minerals) or are produced only over many millions of years are called

non-renewable resources, such as *fossil fuels*. Non-renewable resources may be recyclable so that their usefulness to human beings can be extended, but often they are transformed during use into useless matter such as waste gas.

• 1.3. FOREST RESOURCES

Forest (*Latin* : Foris = out of door) means a *plant community which predominantly consists of trees and other vegetation usually with a closed canopy.* On land, the forests generally vary in density and composition. The **deodar forests** of Himachal Pradesh and Kashmir are evergreen, while some are deciduous which become leafless either before the onset of intense dry summer, *e.g.*, **teak forests** in Madhya Pradesh or before the onset of winter, *e.g.*, **oak forests** in the Himalayas. This reduces the transpiration to the minimum.

[I] Types of Forests

The types of forests depend on temperture, rainfall, climate etc. Following are some of the important Indian forests.

(1) **Moist tropical forests :** These forests are also known as evergreen forests, as they remain evergreen throughout the year, *e.g.*, *irul, toon, dipterocarps* etc. These forests are mainly found in Assam, Andamans and Western Ghats.

(2) **Dry tropical forests :** These forests consist of plants which have fleshy stems and leaves. These are generally found in regions having an annual rainfall between 75 and 125 cm. These forests are found in U.P., M.P., Rajasthan, Gujarat, Punjab.

(3) **Montane sub-tropical forests :** These forests occur at a height of 700–1800 m in the Himalayan regions of U.P. and Nilgiris (South).

(4) **Montane temperature forests :** These forests occur at a height of 1800–2700 m having an annual rainfall of 125–200 cm. Such forests are found in Orissa and Bihar.

(5) **Subalpine forests :** These forests consist of shrubs and small trees. They are found at a height of 2800–3500 m.

(6) **Alpine scrub forests :** These forests are also called evergreen forests with trees of small stems. These are found at a height above 3500 m in the Himalayas.

[II] Botanical Classification of Forests

According to botanists, Indian forests can be classified into the following categories :

(1) **Hill forests :** These forests are found in Himalyas above 3000 ft. sea level and in South India above 5000 ft. sea level. The trees include *pines, oak, walnut, chestnuts, elm, maple, picea etc.* Besides these, *rhodo, laurels* and poplars also grow in abundance.

(2) **Trial or littoral forests :** These forests are excellent source of fire wood and fuel. These are found in the estuaries of rivers like Ganga, Mahanadi, Indus and Sutlej.

(3) **Dry forests :** The desert areas of Punjab and Rajasthan have the forests where rain occurs about 75 to 125 cm annually. The plants have thick and fleshy stems and thick leaves.

(4) **Deciduous forests :** These forests have trees like *sal, sandal wood, teak, padauk* etc. The forests occur in regions with an annual rainfall between 130–200 cms.

(5) **Evergreen forests :** These forests are found in sub Himalayan regions and in Western Ghats. *Bamboos, toon, irul* etc. are found in these forests.

[III] Uses of Forests

(1) More than 150 species of bamboos out of 370 present in the world are found in Indian forests which are mainly used by poor persons for roofing, flooring, walling, matting, sports goods and many other purposes. Some types of bamboos are used for making rayon, paper, furniture, rope, suspension bridges, bangle boxes, air

cooled pipes and magical instruments. The bamboo forests are found in Uttar Pradesh, Bihar, Maharastra, Orissa, Kerala, Tamilnadu, Assam, Andaman and Nicobar. Bamboos can be defined as *tall, perennial arborescent grasses characterised by woody stems called culms.*

(2) Most of the ecologically useful plants like *shrubs, climbers* and *grasses* of the forests check soil erosion and are also cheap sources of fodder for animal and provide shelter to wild life.

(3) Forests reduce the soil run off. The rain water is first absorbed by humus and then slowly and slowly it seeps into the sub-soil and finally goes undergroud. In this way, forests are very useful in checking floods.

(4) Forests are responsible for continuous supply of water in the form of springs and wells etc. This is due to absorption of rain water in rainy season and they do not allow the water to evaporate or run off rapidly. Therefore, because of forests and their absorption mechanisms we get water in rivers, springs, streams etc.

(5) Forests are sources of moisture in the environment. It is said that forests attract clouds and cause precipitation.

(6) Forests provide shelter to animals, human beings and thousands of micro-organisms. They also provide opportunity to develop various species of plants. The survival of these plants, animals and micro- organisms is not possible without forests.

(7) Forests are responsible for reducing environmental pollution by absorbing carbon dioxide and other harmful gases. Forests also absorb particulate matter from the atmosphere thus reducing its concentration in the environment.

(8) Essential oils are obtained from a number of forest plants. These are used in the manufacture of soaps, cosmetics, tobacco flavouring, pharmaceuticals, confectionery etc. For example, *eucalyptus, khus, rusa grass* and *sandal wood* are used in medicines.

(9) Drugs, camphor, spices, poisons, insecticides etc. are important forest products. Several forest fruits, flowers and even leaves and roots are eaten. For example, *ber, kaitha, phalsa, jamun, tendu* etc. are eaten as fruits. *Amla, imli, karaunda, kachnar* etc. are used as vegetables and preparing pickles. *Kala zeera* is the seed of *carum carvi* and is used as a spice. *Shahtoot* fruit is used for making sharbat. Tendu leaves are used as wrapper of tabacco to prepare *bidi.* A malaria drug *quinine* is obtained from the bark of *cinchona.* The bark of *arjun* tree is used as a *medicine in checking diabetes. Lac* is also produced from forests.

(10) Forests preserve the soil temperature and the biological activity of the top layer of soil.

(11) The forests check the temperature of the surroundings and make the life happy and gay.

[IV] Deforestation or Forest Destruction

Deforestation means the *complete removal of a forest ecosystem and conversion of the land to another type of landscape.* It differs from *clear cutting* which entails complete removal of all standing trees but leaves the soil in a condition to regrow a new forest if seeds are available. Humans destroy forests for many reasons.

American Indians burned forests to convert them into grasslands that supported big game animals. Early settlers cut and burned forest to convert them into croplands. The major direct causes of topical deforestation are the expansion of shifting agriculture, livestock production and fuelwood harvest in drier regions. Forest conversion to permanent cropland, infrastructure, urban areas and commerical fisheries also occurs. Although not necessarily resulting in deforestation, timber harvest, grazing and fires can severely degrade the forest. Increased demand for paper, newspapers, paper boards, medicines etc. also cause deforestation. Construction of dams, power stations, highways, roads, railways, limestone mines and other projects are also responsible for deforestation. Though dams are meant to

provide cheap electricity, many of them are economic failures due to the lack of environmental planning.

[V] Overexploitation of Forest Resources

India was once covered with extremely dense and productive rich natural forests. But we have overexploited the forest resources, without thinking the ill-effects of deforestation. The *pines* were exported to develop railways to build *sleepers*. Teak from Malabar was cut for the king's navy. The *sal* of Central India and *conifers* of the Himalayas were exploited for the railway system. Horticulture is also responsible for the deforestation process in India. Nearly 270 lakh cubic metres of wood is used anually for packing and transporting horticultural products, like apples from H.P. and Kashmir, mangoes etc. The **National Commision on Agriculture** has shown a substantial increase in the demand of wood by 2007. Wood is used for fruit industry, tea, paper industry, wooden crates, plywood crates etc.

[VI] Effects of Deforestation

The environmental costs of deforestation include species extinction, erosion, flooding, reduced land productivity, desertification and climate change and increased atmospheric carbon dioxide content. As more habitat is destroyed, more species are facing extinctions. Deforestation of watersheds causes erosion, flooding and siltation. Upstream land loses fertile topsoil and downstream crops are flooded, hydroelectric reservoirs are filled with silt and fisheries are destroyed. In drier areas, deforestation contributes to desertification.

Deforestation can change local and regional climates because evaporation of water from leaves makes up as much as two-thirds of the rain that falls in some forests. Without trees to hold back surface run-off and blockwind, available moisture is quickly drained away and winds dry the soil, sometimes resulting in desert like conditions. Another potential effect on climate is the large scale release into the atmosphere of carbon dioxide stored as organic carbon in forests and forest soils. In 1980, tropical deforestation released between 0·4 and 1·6 billion tons of carbon into the atmosphere an amount equal to 10–40% of that from fossil fuels.

Due to misguided deforestation in the moist and dry tropics, the rural poor are deprived of construction materials, food, fuel and cash crops harvested from the forest. Species extinctions, siltation and flooding expand these problems to national and international levels. Despite these human and environmental costs, wasteful deforestation continues. Efforts should be made for the reforestation of deforested areas and the establishment and maintenance of biodiversity preserves.

• 1.4. MINING AND ITS EFFECTS

Surface mining techniques are used when a vein of coal or other substance lies so close to the surface that it can be mined with bulldozers, power shovels and trucks instead of using deep shaft mines, explosive devices or coal gasification techniques. A recent estimate showed that in India nearly 30,000 hectares of land has been degraded from mining and another 60,000 hectares of fertile land was eroded to meet our requirements of bricks.

[I] Environmental Effects

Surface mining can have the following severe environmental effects.

(i) The process removes all vegetation, destroying microflora and micro- organisms.

(ii) The soil, sub-soil and strata are broken and removed.

(iii) Wildlife is displaced, air quality suffers and surface changes occur due to oxidation and topographic changes.

(iv) Hydrology associated with surface mining has a major effect on the environment. Removal of overburden may change the groundwater in a number of ways, including drainage of water from the area changing the direction of aquifer flow and lowering the water tables.

(v) *Channels are created which allow contaminated water to mingle with water of* other aquifers. Acid water run-off from the mining operations can contaminate the area and other water sources. In addition to being highly acidic, the run-off from mining operations also contains many other trace elements that adversely affect the environment.

(vi) The removal of vegetation and overburden at the mining site displaces all *wildlife and a large portion of it may be completely destroyed.*

(vii) Ponds, streams and swamps are routinely drained before mining operations start and all aquatic life in the region is destroyed.

(viii) Surface mining has long term impact on the flora and fauna within the region of the mine. Salts, heavy metals, acids and other minerals exposed during removal of overburden suppress growth rate and productivity. Due to changes in soil composition, many native species of plants are unable to adjust. The loss of vegetation means a loss of feeding grounds which in turn disrupts migration patterns. Displaced species encroach on neighbouring ecosystems which may cause overpopulation and disruption of adjacent habitats.

A development plan should be blended with action under the aegis of '**National Wasteland Development Programme**'. It should take climate, soil texture, rainfall pattern, timber, population explosion and other bio-mass needs.

[II] Non-Government Organizations—Objectives and Role

To initiate environment awareness among people, several non-government organizations (NGO) and voluntary organizations have come up, *e.g.*, Chipko movement, (1970), Appiko Movement, Academy of Environmental Sources (1980), Indian Society for Naturalist, Gujarat (1975), Society for Himalayan Environmental Rehabilitation and People Action (1984) etc.

(1) Objectives of NGO's : Following are some main objectives of non-government organisations.

(a) Environmental pollution control

(b) Environmental education and awareness among people especially children

(c) Conservation of wild life and biological diversity.

(d) Rural development

(e) Protection of forests

(f) Afforestation and social forestry

(g) Emphasis on the use of non-conventional, pollution free sources of energy instead of thermal, hydel and nuclear energy.

(h) Encouraging the use of biofertilizers

(i) Sustainable development

(j) Emphasis on family planning and population control

(k) Recycling and waste utilization

(l) Emphasis on healthy cropland and grassland.

(2) Role of NGO's in Conveying Environmental Education : The important means in which the NGO's can be helpful are to aid and advise the government agencies on environmental education, so that they may act as eyes and ears of the government. The NGO's should educate the people and to create general awareness among the public in farour of conservation.

(3) Some Important NGO's :

(i) Kalpavriksh (KV) : This movement started in 1979 as a move to oppose the destruction of Delhi's green regions. The important tasks of KV are to create understanding and concern on environmental issues, especially among the youth. KV is currently engaged in research on environmental subjects, such as an impact assessment, study of Narmada Valley Project, air pollution in areas of Delhi, pesticide use in India and mining activities. KV is

working as a resource group for NCERT and other important agencies working on environment education.

(ii) World Wide Fund for Nature : The World Wildlife Fund (WWF) is an international conservation organization founded in 1961 and known internationally as the World Wide Fund for Nature. The WWF acts with other US organizations in a network to conserve the natural environment and ecological processes essential to life. Particular attention is paid to exdangered species and to natural habitats important for human welfare. WWF has articulated nine goals that guide its works :

(i) To protect habitat
(ii) To protect individual species
(iii) To support scientific investigation
(iv) To promote ecologically sound development
(v) To promote education in developing countries
(vi) To encourage self-sufficiency in developing countries
(vii) To provide training for local wild life professionals
(viii) To monitor international wild life trade
(ix) To influence public opinion and the policies of governments and private institutions.

Recent WWF projects include programmes to save the African elephant, giant panda under the trade regulations of the **Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).** WWF started its activities in Mumbai (1970).

(iii) Kerala Sastra Sahitya Parishad : The main activities of the Parishad are ecodevelopment, creating awareness on water and energy conservation, encouraging the use of non-conventional sources, *e.g., smokeless chulhas.* As an acknowledgement of the outstanding work for the protection of environment, the Parishad was awarded Indira Gandhi Paryavaran Puraskar (1988).

(iv) Chipko Andolan Movement : During the British occupation, the right of peasants in India to gather products, including forest materials was severely curtailed. Trees were felled on a large scale to build ships for the British Royal Navy or to provide ties for the expanding railway network in India, severely depleting forest resources on which traditional cultures had long depended. In response to British rule with its forest destruction and impoverishment of native people, a series of non-violent movements utilizing *satyagraha* spread throughout India. The British and local aristocracy suppressed these protests brutally, massacring unarmed villagers by the thousands and jailing Mahatma Gandhi a number of times, but Gandhi and his allies remained steadfast in their resistance.

After India gained independence, two of Gandhi's disciples, Mira Behn and Sarala Behn, moved to the foothills of the Himalayas to establish *ashramas* (spiritual retreats) dedicated to raising women's status and rights. Their project was dedicated to four major goals :

(a) Organizing local women
(b) Compaigning against alcohol consumption
(c) Fighting for forest protection
(d) Setting up small, local, forest based industries.

During the 1970s, commerical loggers began large scale tree felling in the Garhwal region in Uttaranchal in northern India. Landslides and floods resulted from stripping the forest cover from the hills. The firewood on which local people depended was destroyed, threatening the way of life of the traditional forest culture.

In April 1973, village women from the Gopeshwar region who had been educated and empowered by the principles of non-violence devised by the Behns began to confront loggers directly, wrapping their arms around trees to protect them. The outpouring of support sparked by their actions dubbed the *Chipko Andolan Movement* (literally, movement to hug trees). This crusade to save the forests eventually prevented logging on 12,000 sq km of sensitive watersheds in the Alaknanda basin. Today, the Chipko Andolan Movement has grown under

the leadership of famous environmentalist Sundar Lal Bahugana to more than 4000 groups working to save India's forest and environment. Their slogan is, *"what do the forest bear? Soil, water and pure air"*.

The successes of this movement, both in empowering local women and in saving the forests on which they depend, are inspiring models for grassroots green movements around the world.

(v) Appiko Movement : The famous *Chipko Andolan* of Uttaranchal in the Himalayas inspired the villagers of the Uttra Kannada district of Karnataka in South India to launch a similar movement to save the forests. In September 1983, men, women and children of Salkani forest in Sirsi district hugged the trees of *Kalase forest*. The local term for hugging in Kannada is *appiko*. This Andolan gave birth to a new awareness all over southern India.

In 1950, Uttara Kannada district forest covered more than 81% of its geographical area. The government declared this forest district a backward area. Then a process was initiated to develop the area by coustructing a pulp and paper mill, a plywood factory and a chain of hydroelectric dams. These industries have overexploited the forest resources and the dams have submerged huge forest and agricultural areas. By 1980, the forest had shrunk to nearly 25%.

In 1983, started the Appiko Movement which aimed to utilize the people's energy to protect and plant trees and to teach the people to limit the use of forest resources to a minimum. The activists have constructed 2000 fuel efficient chulhas in the area which save fuel wood consumption by almost 40%. These chulhas are installed in hotels, reducing firewood consumption. The people connected with this movement do not want a total ban on felling of trees. They want that there should be rules and restriction, *e.g.*, local people should be consulted before the trees are felled.

• 1.5. WATER RESOURCES

Seventy one percent of the earth's surface is covered by water—an area called the *hydrosphere*, which makes up all of the oceans and seas of the world. Only 3 percent of the earth's entire water is fresh water. This includes Arctic and Antarctic ice, groundwater and all the rivers and fresh water lakes. The amount of usable fresh water is only about 0003 percent of the total. This relatively small amount of fresh water is recycled and purified by the hydrologic cycle, which includes evaporation, condensation, precipitation, run-off and percolation, since most of life on earth depends on the availability of fresh water, one can say '***water is life***'.

[I] Utilization of Water

Worldwide, agricultural irrigation uses about 80 percent of all fresh water. Cooling water for electric power plants, domestic and other industry use the remaining 20 percent.

[II] Conservation of Water

The water conservation may be accomplished by improving crop water utilization efficiency and by decreasing the use of high water demanding crops and industrial products.

[III] Freshwater Sources

Freshwater sources are either surface water (river and lakes) or ground water. Water that flows on the surface of the land is called **surface run off**. The relation between surface run-off, precipitation, evaporation and percolation is given by the following equation :

$$\text{Surface run-off} = \text{Precipitation} - (\text{Evaporation} + \text{Percolation})$$

When surface run-off resulting from rainfall or snow melt is confined to a well defined channel, it is called a **river** or ***stream run-off***.

[IV] Groundwater

Groundwater is surface water that has permeated through the soil particles and is trapped among porous soils and rock particles such as sandstone or shale. The upper zone of

saturation where all pores are filled with water is the ***water table***. It is estimated that the groundwater is equal to forty times the volume of all earth's freshwater including all the rivers and freshwater lakes of the world.

The movement of groundwater depends on the porosity of the material that holds the water. Most groundwater is held within the sedimentary aquifers. Aquifers are underground layers of rock and soil that hold and produce an appreciable amount of water and can be pumped economically.

[V] Water Requirements In India

Table-1 gives an idea about the water requirement in the past and future for various projects. (All quantities are in cubic kilometers)

Table-1

Water needed for	1974	2000	2025
Irrigation	350.0	635.0	770.0
Industries	5.5	30.0	120.0
Domestic needs	8.8	26.6	39.0
Thermal power generation	11.0	60.0	160.0
Livestock management	4.8	7.5	11.0
Total	380.1	759.1	1100.0

We currently have the technology to solve most water resource problems. Implementing solutions are often constrained by inadequate policies, institutions financial resources and political instability. In several ways, people managment is more critical than water resource management. With human populations continuing to grow, water scarcity, flooding and disease and death from contaminated drinking water will become even more pronounced.

• 1.6. FLOODS

Technically, *flood is a process when the water level in any stream, river, bay or lake rises above bank full.* Bays may flood as the result of a *tsunami* or tidal wave induced by an earthquake or volcanic eruption or as a result of a tidal storm surge caused by a hurricane or tropical storm moving inland. Historical evidence suggests that flooding causes greater loss of life and property than any other natural disaster. The magnitude, seasonality, frequency, velocity and load are all properties of flooding which are studied by meteorologists, climatologists and hydrologists.

[I] Causes of Flooding

Five climatic features contibute to the spring and winter flooding potential of any individual year or region.

(i) Heavy winter snow cover

(ii) Saturated soils or soils at least near their field capacity for storing water.

(iii) Rapid melting of the winter's snow pack in snow fed areas of North India.

(iv) Frozen soil conditions which limit infiltration.

(v) Somewhat heavy rains, usually from large scale cyclonic storms.

Besides the above the other causes of flooding may be anthropogenic, *e.g.*,

(a) Sedimentation, which is the main reason for flooding in Brahmaputra river. Increased surface run-off also accelerates the rate of soil erosion and sediment load of the rivers.

(b) Large scale deforestation in the upper catchment of the major rivers. It leads to excessive flow of water to the plains, causing floods.

(c) Accumulation of wastes, sewage, garbage, filling of urban drains, gradual encroachment of human settlements near the channels etc. also cause floods.

(d) Man made activities such as building construction, urbanization, channel manipulation through diversion of river course, construction in bridges, reservoirs etc. also contribute to flooding of rivers.

This type of flooding can cause hundred of millions of rupees in property damage, but it can usually be predicted well in advance, allowing for evacuation and other protective action to be taken, *e.g.*, sand bagging. In some situations, flood control measures such as stream or channel diversions, dams and levees can greatly reduce the risk of flooding. This is more often done in floodplain areas with histories of very damaging floods. In addition, land use regulations, encroachment statutes and building codes are often meant to protect the public from the risk of flooding.

[II] Flash Floods—Causes and Effects

Flash flooding is generally caused by violent weather, such as severe thunderstorms and hurricanes. This type of flooding more frequently occurs during the warm season when convective thunderstorms develop more frequently. Rainfall intensity is so great that the carrying capacity of streams and channels is rapidly exceeded, usually within hours, resulting in sometimes life threatening flooding. Many flash floods occur as the result of afternoon and evening thundershowers which produce rainfall intensities ranging from a few tenths of an inch per hour to several inches per hour. In some highly developed urban areas, the risk of flash flooding has increased over time as the native vegetation and soils have been replaced by buildings and pavement which produce much higher amounts of surface run-off.

[III] Flood Control Measures

(i) Non-structural measures : Physical control methods, *e.g.*, embankment, flood walls, ring bunds, dams and drain channels cannot provide protection to all the flood prone areas of the country. By constructing a dam, the nearby people suffer more damage during flooding than what they would have suffered had the structure not been constructed.

(ii) Forecasts : Flood forecasting may reduce the impact of floods.

(iii) Flood plain zoning : The aim of flood plain zoning is to regulate the land use in flood prone areas so as to restrict the damage by floods. It determines the locations and extent of areas likely to be damaged by floods.

(iv) Flood proofing measures : The construction of industries, public utilities, railway tracks, electricity installations, airports etc. be made above the observed flood levels, so that they may remain unaffected in case of flooding.

(v) Flood risk maps : The zones be demarcated for various flood frequencies with the help of data and maps.

(vi) Flood management schemes : Commisions have been set up by the central government to do the frame work for integrated flood management schemes. Recently, **Ganga Flood Control Commission** and the **Brahmaputra Board** have been set up for flood control.

(vii) Afforestation : Floods can be controlled by large scale afforestation in hilly areas. It will reduce the sediment load of river and encourage more infiltration of rain water.

(viii) Storage reservoirs : For controlling the floods, storage reservoirs can be used, *e.g.*, on Miami river in Ohio (USA), **Damodar Valley Corporations** (DVC) generates hydroelectricity and provide water for irrigation purposes, besides controlling floods.

[IV] Basic Safety Precautions to be Taken During Floods

1. Listen to radio/TV for the latest weather bulletins and flood warnings. Pass on the information to others.
2. Make a family emergency kit which should include; a portable radio/transistor, torch, spare batteries, a first aid box along with essential medicines, ORS, dry food items, drinking water, matchboxes, candles and other essential items.
3. Keep hurricane lamp, ropes, rubber tubes, umbrella and bamboo stick in your house. These could be useful.
4. Keep your cash, jewellery, valuables, important documents etc. in a safe place.
5. If there is a flood, move along with your family members and cattle to safe areas like relief camps, evacuation centres, elevated grounds where you can take shelter.
6. Turn off power and gas connections before leaving your house.

During floods :

- Don't enter into flood waters; it could be dangerous.
- Don't allow children to play in or near flood waters.
- Stay away from sewerage line, gutters, drains, culverts etc.
- Be careful of snakes; snakebites are common during floods.
- Stay away from electric poles and fallen power-lines to avoid electrocution.
- Don't use wet electrical appliances-get them checked before use.
- Eat freshly cooked and dry food. Always keep your food covered.
- Use boiled and filtered drinking water.
- Keep all drains, gutters near your house clean.
- Stagnation of water can breed vector/water-borne diseases. In case of sickness, seek medical assistance.
- Use bleaching powder and lime to disinfect the surroundings.

1.7. DROUGHT

[I] Definition

In terms of Indian Meteorological Department, drought can be defined as *a situation when the average annual rainfall is less than 75 percent of the normal rainfall and there is a shortage of surface or ground water affecting the plant and animal life adversely.* Of all natural disasters drought is the subtlest. Often farmers cannot tell there is going to be drought until it is too late. Unlike flash floods, drought is slow to develop. Unlike earthquakes, with destruction to the exterior environment, drought does its damage underground long before dust storms rage across the plains.

[II] Measurement of Drought

Technically, drought is measured by the decrease in the amount of subsoil moisture that causes crops to die or yield less (agricultural drought) or by a drop in the water level in surface reservoirs and below ground aquifers, causing wells to go dry (hydrological drought). Agricultural plus hydrological drought can lead to sociological drought. In this condition, drought affects food and water supplies to the extent that people have to rely on relief donations or are forced to migrate to another areas.

Droughts are worldwide, repetitive and unpredictable. Scientists believe there is a drought somewhere on the earth at any time.

[III] Causes of Drought

The direct cause of drought is a continued decrease in optimal rainfall. But what causes clouds not to form over an area, or the winds to carry rain-bearing clouds elsewhere, is complex. Climate change will change the location of increased and reduced rainfall, so that some places that have always been well-watered will experience drought. Drought prediction is still in its infancy.

(i) Lack of rain, for example, in the Sahel region is exacerbated by man-made environmental problems, such as cutting down trees for fuel and not allowing the soil to lie fallow, which conserves soil moisture.

(ii) Overgrazing by animals such as cattle, goats and sheep also contributes to the denuding of topsoil, which blows away in the wind, a condition known as ***desertification***. Drought then becomes a cycle that feeds on itself, lack of trees reduces the amount of water vapour given off into the atmosphere, lack of topsoil reduces water retention. The result is that local rainfall is reduced and the rain that does fall run-off and is not absorbed.

[IV] Impacts of Drought

Drought affects all types of life forms in the biospheric ecosystem as follows :

(i) It creates acute shortage of drinking water.

(ii) It creates scarcity of food, fodder and fuel.
(iii) There is a loss of standing crops.
(iv) Several birds/animals migrate to other safer places.
(v) There is a loss in hydroelectric power generation.
(vi) Agrobased industries are badly affected.
(vii) Employment problem becomes acute.
(viii) There is an increase in imports etc.

[V] Measures to Control Drought

Following measures can be undertaken to combat drought conditions :

(i) Distributing water from more to less abundant supplies by laying pipes and installing pumps within a state or a country.
(ii) Farmers should invest in high-tech irrigation techniques or alter their crops to grow low-water plants, such as garbanzo beans.
(iii) Drought causing industrial pollutants that '*freeze*' the water supply by rendering it toxic should be reduced and resolved under a penal law.
(iv) Dry farming techniques should be developed.
(v) Schemes should be introduced and investigated which conserve water.
(vi) Afforestation should be carried out to the maximum.

In India, a drought prone area programme was launched in 1998, especially in arid and semi-arid zones which have poor natural resource endowments.

• 1.8. DAMS

[I] Benefits

Most dams are built to control flood hazards, to store water for irrigation or other uses or to produce electricity. In India, where nearly 75 percent of the population depends on agriculture, the execution of River Valley Projects and dam building are some important steps of growth strategy.

Where dams are needed for power, they can have a positive effect in offsetting environmental costs associated with other power sources. Hydropower is cleaner and safer than nuclear power. Water turbines are also cleaner than coal-fired generators. Furthermore, both nuclear and coal power require extensive mining with environment costs far more severe than those of even a large dam.

[II] Effects on Forests and Tribal People

(i) Dams provide environmental costs including riparian habitat loss, water loss through evaporation and seepage, erosion and declining water quality. Farther reaching consequences of dams include changes in groundwater flow and the displacement of human populations.
(ii) Riparian or stream-side, habitats suffer both above and below dams. Valuable ecological zones that support specialised plants, riparian environments and nearby shallows provide food and breeding grounds for birds, fish and many other animals. Upstream of a dam, impounded water drown riparian communities. Because reservoirs can fill hundreds of kilometres of river channel and because many rivers have a long sequence of dams and reservoirs, habitat drowning can destroy a great deal of river biodiversity. Downstream, shoreline environments dry up because of water diversions (for irrigation or urban use) or because of evaporation and seepage losses in the reservoir.
(iii) Dams interrupt the annual floods that occur naturally on nearly all rivers. Seasonal flooding fertilizes and water flood plains and clears or redistributes debris in river channels. These beneficial effects of flooding stop once a river is *dammed.*

(iv) Dams and reservoirs change sediment deposition in rivers. Most rivers carry large amounts of suspended silt and sand and dams trap sediments normally deposited downstream. Below the dams, erosion reshapes river channels once sediment deposition stops. If erosion becomes extreme, bridges, levees and even river deltas can be threatened. Meanwhile, sediment piling up in the still waters of the reservoir behind the dam decrease water storage capacity.

(v) An increasingly shallow reservoir also becomes gradually warmer. Oxygen content decreases as the water temperature rises, fish populations fall and proliferating algae and aquatic plants can start blocking the dam's water intakes. In arid zones, a higher percentage of river water evaporates as the reservoir becomes shallower. Evaporating water leaves behind salts, which further decrease water quality in the reservoir and river.

(vi) Water losses from evaporation can be extreme. Water losses also result from seepage into bedrock. As river water enters groundwater, water tables usually rise around a reservoir. In arid areas increased groundwater can increase local fertility, sometimes endangering delicate dry-land plant species. In moister regions, excessive groundwater can cause swamping. Evaporation from exposed groundwater can leave higher salt concentrations in the soil. The most catastrophic results of reservoir seepage into groundwater occur when saturated rock loses its strength. In such cases, valley walls can collapse, causing dam failure and disastrous flooding downstream.

(vii) The most significant environment effect of dams results from the displacement of human populations. Because people normally settle along rivers, where water for drinking, power, irrigation and transport are readily available, reservoir flooding can displace huge populations. A series of dams on India's Narmada river will inundate the homes of 1·5 million people along with 6,00,000 acres of farm land. In such cases, people will need to find new places to live and clear new land to grow food.

[III] Some Dams

(i) Aswan High Dam : A heroic symbol and an environmental liability, Aswan High Dam on Nile River (Egypt) was completed in 1970. It was built as a symbol of national strength and modernity. By increasing industrial and agricultural output the dam generates foreign exchange for Egypt, raises the national standard of living and helps ensure the country's high status and profile in international affairs.

(ii) Bhakra Dam : It is located near Bhakra village in Bilaspur district (Himachal Pradesh) and is built on Satluj river. It provides irrigational water and hydropower.

(iii) Hirakud Dam : It is located in Hirakud in Sambalpur district (Orissa) and is built on Mahanadi river. It generates hydropower and controls floods.

(iv) Sharavathi Hydroelectric Project : It harnesses famous *Jog Falls* in Karnataka and is built on a short westward flowing river, Sharavathi. It generates hydel power.

(v) Mettur Dam : It is located in Mettur (Tamilnadu) and built on Cauvery river. It is used for irrigation purposes and generates hydropower.

(vi) Rihand Dam : It is located at Pipri in Mirzapur district of U.P. It is built on Rihand river, which is a tributary of river Son. It produces hydel power. Besides the above, other dams and projects in India are :

(a) Nagarjuna Sagar Dam : Nandi Konda village, Nalgonda, A.P. on Krishna river. Used for irrigation and hydel power.

(b) Kosi Project : Barrage on river Kosi (tributary of Ganges) near Hanuman Nagar, Indo-Nepal border. Used for irrigation, power and flood control.

(c) Chambal Valley Project : Gandhi Sagar (M.P.), Rana Pratap Sagar, Jawahar Sagar and Kota barrage in Rajasthan, built on Chambal river (tributary of Yamuna). Used for irrigation and power.

(d) Damodar Valley Project : All dams lie in Bihar, but Durgapur barrage is in West Bengal. Built on Damodar and Hooghly rivers. Used for irrigation, power and flood control.

• 1.9. MINERAL RESOURCES

Mineral resource refers to a large variety of materials obtained from earth. A nation's prosperity depends largely on its mineral resources.

[I] Types of Minerals

There are two types of minerals, *viz.*,

(a) Metallic minerals : These minerals when processed give metals like copper, aluminium, silver, gold etc.

(b) Non-metallic minerals : These minerals give products other than metals, *e.g.*, soda ash, clay, sand, phosphatic rocks, coal, oil, natural gas etc.

[II] Formation of Mineral Deposits

Mostly, minerals and their decomposition products are distributed in earth's crust. Mineral deposits are formed by slow biological or geochemical processes, *e.g.*, formation by evaporation of sea water, oxidation-reduction process, microbial activities, concentration of minerals during sedimentation, transport and weathering etc.

[III] Use of Mineral Resources

Several metals like copper, lead, zinc, nickel, silver etc. are extracted from their ores and used by man for different purposes. Iron has been obtained from its ore (haematite) and used tremendously. When mixed with carbon, it forms steel—another important product. Today, the total quantity of all metallic and non-metallic substances obtained from earth amounts to nearly 200 billion tonnes. Major part of world's mineral resources is still being used by rich and developed nations. With the increasing demand of minerals, trermendous strain is borne on the mineral resources of the world.

[IV] Exploitation of Mineral Resources

Excessive consumption of mineral wealth may have drastic effects on the entire biosphere.

(i) Rapid depletion of high grade mineral deposits : The ever rising demand of metals are compelling miners to mine out low grade deposits of ores. This involves a large amount of energy expenditure as well as large quantity of waste materials. Most of the metals are present in the soil, rocks, trash or waste products in highly dispersed state. Modern techniques should be used, but it will increase the cost of mining, making the metals costlier.

(ii) Wastage and dissemination of mineral resources : Mostly, our mineral deposits occur as a complex substance. After the removal of the top soil, the desired mineral is dug out leaving behind other elements as waste materials. Extraction of one element is made at the cost of others which are in short supply. World wide smelting processes for extracting the metals release huge quantities of sulphur and heavy metals like lead, arsenic, mercury, cadmium, zinc etc. into the environment. This deteriorates the quality of water and soil. So, industries should extract metals by using advanced technology without digging out fresh deposits.

(iii) Pollution production by heavy energy sources : In order to remove silt, clay, sand and in concentration of ore, roasting, smelting operations, an enormous amount of energy is required. The energy comes from different sources like fire-wood, petroleum, coal, natural gas etc. These energy sources on burning produce gaseous pollutants like CO, CO_2, NO_2, SO_2 etc. in atmosphere. These gaseous emissious may be noxious, toxic or in the case of the oxides, precursors of acid rain.

[V] Mining Process

The mining and processing of minerals involves the following steps :

(i) The soil and rock overlying the mineral deposits have to be removed before starting the mining operations.

(ii) The ore is then mined and crushed to small pieces.

(iii) The mined and powdered ore is then concentrated to remove impurties.

(iv) The concentrated ore is then roasted (or calcined) and reduced to crude metal.

(v) The crude metal is then refined by various processes to give pure metal.

[VI] Environmental Effects of Extraction

(i) Run-off from mine tailings may wash hazardous materials into nearby surface or subsurface water resources. Occasionally, processing wastes are discharged directly to the receiving water body, where they impair water quality and affect aquatic life. The most obvious impacts of mining on the lithosphere are :

(1) the residues from the dumping of tailings and processing wastes directly on the landscape and

(2) the disruption of many activities, such as agriculture, forestry and recreation, particularly from open-pit mining and quarrying.

(ii) The impact of the mining industry on human health and well being is a subject of much debate. However, the adverse effects of the sustained exposure of miners to minerals such as coal (causing *black lung disease*) and asbestos (causing *absestosis*) have been estabilished beyond doubt.

(iii) Noise pollution from mining or quarrying operations near inhabited areas may *also have negative effects on the health and well being of the local population.*

(iv) Environmental impacts of mining include the creation of new land forms, severe ecosystem disruption and the formation of dangerous chemicals. Ecosystem disruption stems mainly from loss of topsoil, rich in organisms and nutrients, sterile landscapes with high sediment run-off are a common outcome.

(v) The most serious problem resulting from *mine wastes is acid drainage and* leaching of hazardous substances. When these wastes are moved from a reducing environment (oxygen deficient) to an oxidising environment, sulphuric acids are formed by the oxidation of the sulphides in metallic ores or the sulphur that commonly accompanies coal deposits. These acids may flow into surface waters *or may leach hazardous metals from the wastes. The best solution is to minimise* exposure to oxygen, usually by burial.

[VII] Conservation of Mineral Resources

The mineral resources can be conserved by adopting the following steps :

(i) *Economy in the use of mineral resources.*

(ii) Renovation, recycling and reuse of metals.

(iii) Search of new earth's treasure.

(iv) Protecting the exsisting mineral resources.

(v) Using modern techniques to recover metals from minerals.

(vi) Making the finished products to last longer.

(vii) Use of less precious substitutes.

(viii) Quarrying should be carried out with utmost care using latest machines.

[VIII] Mineral Resources in India

India is very rich in mineral resources. Iron minerals, aluminium reserves, zinc-lead ores, monazite sand (thorium), gold, aluminium, silver, copper, lead, manganese, chromium, titanium, cobalt, tin etc. are found in abundance.

• 1.10. FOOD RESOURCES

[I] World Food Problems

We know that due to global population explosion, the need of food problems has taken a serious view. This has led to manipulation of land resources causing a stress in the natural

environment. Efforts have been made to increase the crop production to tackle the world food problems. There was 110 percent increase in the yield of IR–8 and 195 percent in TN–1 types when grown under plant protection umbrella. The use of fertilizers and pesticides helped in boosting the crop production. The pesticides helped in the eradication of diseases which is an essential part in having a good crop production to meet the requirements of over-populated world.

[II] Overgrazing—Effects and Elimination

Overgrazing is one of the most critical environmental problems facing the mankind In addition to consuming vegetation, cattle alter the ecosystem by tramping, urination, defecation and trashing. Degradation due to heavy livestock grazing continues to occur in many diverse and fragile ecosystems, including savanna, desert, meadow and alpine communities. Cattle eat the seedlings of young trees, which has led to the elimination of some species and this has reduced the species of birds in these areas and disrupted migratory patterns. Lack of new tree growth in these areas has also resulted in the drying up of stream beds and the loss of habitat for fish and amphibians. It has contributed to the problem of soil erosion, desertification and the greenhouse effect.

Elimination of overgrazing : Environmentalists argue that it is possible to eliminate overgrazing. They advocate above all the reduction of herds. They also suggest that cattle should not be allowed to roam at will and should be rotated among various pastures, so that all rangeland areas can receive back-to-back spring and summer rest.

[III] Modern Agriculture and Agricultural Pollution

The development of modern agricultural practices is one of the great success stories of applied sciences. Improved ploughing techniques, new pesticides and fertilizers and better strain of crops are among the factors that have resulted in significant increases in agricultural productivity.

Yet these improvements have not come without cost to the environment and sometimes to human health. Modern agricultural practices have contributed to the pollution of air, water and land. Air pollution may be the most memorable, if not the most significant, of these consequences.

A more serious type of agricultural pollution are the solid waste problems resulting from farming and livestock practices. Authorities estimate that slightly over half of all the solid wastes come from a variety of agricultural activities. Some of these wastes pose little or no threat to the environment. Crop residue left on cultivated fields and animal manure produced on rangelands, for example, eventually decay, returning valuable nutrients to the soil.

Run-off from agricultural land is another serious environmental problem posed by modern agricultural practices. Run-off constitutes a non-point source of pollution. Rainfall leaches out and washes away pesticides, fertilizers and other agricultural chemicals from a wide spread area.

Environmental scientists are especially concerned about the effects of agricultural pollution on groundwater. Groundwater is polluted by much the same mechanisms as is surface water, and evidence for that pollution has accumulated rapidly in the past decade. Groundwater pollution tends to persist for long periods of time. Water flows through an aquifer much more slowly that it does through a river and agricultural chemicals are not flushed out quickly.

[IV] Fertilizers

Any substance that is applied to land to encourage plant growth and produce higher crop yield is known as a fertilizer. Fertilizers may be made from organic material—such as recycled waste, animal manure, compost etc. or chemically manufactured. Most fertilizers contain different amounts of nitrogen, phosphorus and potassium, inorganic nutrients that plants need to grow.

Since the 1950s crop production worldwide has increased dramatically because of the use of fertilizers. In combination with the use of pesticides and insecticides, fertilizers have greatly improved the quality and yield of such crops such as corn, rice, wheat and cotton. However, overuse and improper use of fertilizers have also damaged the environment and affected the health of humans, animals and plants.

Fertilizers are also carried away as run-off. Fertilizer run-off has contaminated groundwater and polluted bodies of water near and around farmlands. High and unsafe nitrate concentrations in drinking water have been reported in countries that practice intense farming, including USA. Accumulation of nitrogen and phosphorus in waterways from chemical fertilizers has also contributed to the eutrophication of lakes and ponds. Ammonia released from the decay of fertilizers, causes minor irritation to the respirator system. The use of organic fertilizers including animal waste, crop residues or grass clippings is also encouraged as an alternative to chemical fertilizers.

[V] Pesticides

A pest is any organism that humans consider destructive or unwanted. ***Pesticides are chemicals that are used to kill insects, weeds and other organisms to protect humans, crops and livestock.***

(1) Benefits of Pesticides : There have been many substantial benefits of the use of pesticides. The most important of these have been :

(a) An increased production of food and fibre because of the protection of crop plants from pathogens, competition from weeds, defoliation by insects and parasitism by nematodes.

(b) The prevention of spoilage of harvested, stored foods.

(c) The prevention of debilitating illnesses and the saving of human lives by the control of certain diseases.

Unfortunately, the considerable benefits of the use of pesticides are partly offset by some serious environmental damages. There have been rare but spectacular incidents of toxicity to humans, as occurred in 1984 at Bhopal (M.P.) where more than 2,800 people were killed and more than 20,000 seriously injured by a large emmission of poisonous *methyl isocyanate* gas, a chemical used in the production of an agricultural insecticide.

(2) Classification of Pesticides (Pest Target) : Pesticides can be classified according to their intended pest target.

(a) Fungicides : These protect crop plants and animals from fungal pathogens.

(b) Herbicides : These kill weedy plants, decreasing the competition for desired crop plants.

(c) Insecticides : These kill insect defoliators and vectors of deadly human diseases, *e.g.*, malaria, plague, yellow fever and typhus.

(d) Acaricides : These kill mites which are pests in agriculture and ticks which can carry encephalitis of humans and domestic animals.

(e) Rodenticides : These control rats, mice, gophers and other rodent pests of human habitation and agriculture.

(f) Avicides : These kill birds which can depredate agricultural fields.

(g) Antibiotics : These treat bacterial infections of humans and domestic animals.

(h) Nematicides : These kill nematodes, which can be parasites of the roots of crop plants.

(i) Molluscicides : These destroy snails and slugs which can be pests of agriculture or in water bodies the vector of human diseases such as *schistosomiasis*.

The most important use - categories of pesticides are in human health, agriculture and forestry.

(3) Classification of Pesticides (Chemical Structure) : Pesticides can also be classified according to their similarity of chemical structure. The most important of these are :

(a) Inorganic pesticides : These include compounds of arsenic, copper, lead and mercury. Some important inorganic pesticides include *Bordeaux mixture*- a complex pesticide with several copper based active ingredients—used as a fungicide for fruit and vegetable crops and various arsenicals used as non-selective herbicides and soil sterilants and sometimes as insecticides.

(b) Organic pesticides : These are chemically diverse group of chemicals. Some are produced naturally by certain plants but the great majority of organic pesticides have been synthesised by chemists. Some prominent classes of organic pesticides are :

(i) Natural organic pesticides extracted from plants. Important insecticides are the alkaloid nicotine and other nicotinoids, largely extracted from tobacco (*Nicotiana tabacum*) and often used as the salt nicotine sulphate. Another insecticide is pyrethrum, a complex of chemicals extracted from the daisy like *Chrysanthemum Cinerarial folium.*

(ii) Synthetic organo-metallic fungicides such as organomercurials, including methylmercury.

(iii) Phenols used as fungicides in the preservation of wood, *e.g., pentachlorophenol.*

(iv) Chlorinated hydrocarbons, expecially the insecticides DDT, DDD and methoxychlor.

(v) Organophosphorus pesticides which are a diverse group of chemicals. Organophosphates have a high acute toxicity to anthropods but a short persistence in the environment. Some other important insecticides are parathion, fenitrethion, malathion and phosphamidon. Glyphosate, an important herbicide is not very toxic to animals.

(vi) Carbamate pesticides, generally have a high acute toxicity to anthropods but a moderate environmental persistence. Important examples are carbaryl, aminocarb and carbafuran.

(vii) Triazine herbicides, *e.g.*, simazine, atrazine and hexazinone are mostly used in corn monoculture.

(c) Biological pesticides : These include bacteria, fungi or viruses that are toxic to pests. One of the most widely used biological pesticide is a preparation manufactured from the spores of the bacterium *Bacillus thuringiensis* or B.t. Because this insecticide has a relatively specific activity against leaf eating lepidopteran pests and a few other insects such as blackflies and mosquitoes, its non-target effects are small.

(4) Ecological Effect of Pesticides : The intended ecological effect of a pesticide application is to control a pest species, usually by reducing its abundance to an economically acceptable level. In a few cases, this objective can be attained without important non-target damage. However, when a pesticide is broadcast sprayed over a field or forest, a wide variety of on-site non-target organisms are affected. In addition, some of the sprayed pesticide invariably drifts away from the intended site of deposition and it deposits onto non-target organisms and ecosystems.

Some of the best known examples of ecological damage caused by pesticide use concern effects of DDT and other chlorinated hydrocarbons on predatory birds, marine mammals and other wildlife. These chemicals accumulate to large concentrations in predatory birds, affecting their reproduction and sometimes killing adults. These have been high profile local and/or regional collapses of populations of *peregrine falcon, bald eagle* and other raptors along with *brown pelican, western grebe* and other waterbirds. It was the detrimental effects on birds and other wildlife, coupled with the discovery of a pervasive presence of various chlorinated hydrocarbons in human tissues, that led to the banning of DDT in most industrialised countries in the early 1970s. These same chemicals are still manufactured and used in some tropical countries.

Some of the pesticides that replaced DDT and its relatives also cause damage to wildlife. For example, the commonly used agricultural insecide carbafuran has killed thousands of waterfowls and other birds that feed in treated fields. However, researchers are in the process of discovering pest specific methods of control that cause little non-target damage and in developing methods of integrated pest management. Not all pest problems can be dealt with in these ways, and there will be continued reliance on pesticides to prevent human and domestic-animal diseases and to protect agricultural and forestry crops from weeds, diseases and depredations caused by economically important pests.

[VI] Water Logging and Salinity

(1) Water Logging : When water stands at a certain place for days together, the crops are damaged. It occurs when the surface of the soil is not even. It is due to the poor drainage in areas with massive irrigation projects. According to NCA (National Commission on Agriculture) water logging has affected nearly 7 million hectares of agricultural land in canal irrigated areas.

(2) Salinity : Soils containing enough soluble salts interfere with the ability of plants to take up water. The conventional measurement that determines the *salinity* of soil is *deciSiemens meter,* Soils are considered saline if the conductivity of their saturation extract solution exceeds 4 deci Siemens meter -1. The most common salts are composed of mixtures of sodium, calcium and magnesium with chlorides, sulphates and bicarbonates. Other less soluble salts of calcium sulphate and calcium and magnesium carbonate may be present as well. The pH is commonly less than 8.5.

Salinity of soil affects the yields of common crops and the level of agricultural production are severely reduced. Salinization can be so severe in some cases that only salt tolerant crops can be grown. Leaching is often necessary to reduce the levels of salt and keep the soil suitable for crop production. But this process can remove other soluble components from the soil and carry them into the waste stream, polluting both groundwater and surface water. So, a method has to be developed for leaching saline soils without these consequences. If this problem is not solved, it will no longer be possible to use some saline soils for agriculture. As population growth continues and the global demand for food increases, another approach might be the development of more salt tolerant plant species.

[VII] Case Studies

The use of pesticides have adverse effects on environment. A large number of persons have died after eating contaminated food due to the use of pesticides. Some cases are cited below.

(i) A dangerous disease *'Handigodu'* was observed in the rural areas of Chikmanglur and Shimoga districts in Karnataka. It was developed due to faulty pesticide application to paddy and coffee fields. The people who took fish, crabs, frogs from the polluted rivers were found to suffer from pain in the hip and knee joints, abnormal growth of bones and abnormal changes in femoral head.

(ii) In Colombia, 80 deaths were reported after consuming flour contaminated with parathion.

(iii) According to a test conducted by **National Cancer Institute,** nearly 80 percent of the animals fed on kepone—a pesticide similar to DDT developed *hepatocellular carcinomas.*

• 1.11. ENERGY RESOURCES

[I] Growing Energy Needs

The world's population and its economic output will continue to grow for at least the next several decades. Much larger growth in both population and gross national product is projected for the less developed countries than for the more developed ones (Barney, 1980). According to World Bank report (1981), three of every four inhabitants of the earth live in the

less developed countries, and two-thirds of these—over 2 billion people—rely on the gathering of wood and crop and animal wastes to provide energy for cooking and warmth.

The world faces substantial increases in energy consumption, particularly in those disadvantaged areas where population growth is still high but individual expectations for improvement are also understandably high. The production of energy brings with it the inevitable consequence of environmental disturbance. Whether we consider the denudation of forests to supply wood for the people of the developing world, or the atmospheric pollution that accompanies the generation of electricity in coal burning power plants, environmental problems grow as energy requirements rise. The purpose is to examine the availability of energy sources in the future and the environmental impacts from increased energy output. In India, per capital consumption of energy is one-fourth of the world average and one twenty fifth that of USA. Traditional sources of energy like animal dung, wood and crop residue account to 30 percent of the total energy consumption in our country, but these are being slowly replaced by modern sources of energy.

[II] Sources of Energy

Energy resources are mainly classified as follows :

***(a)* Primary energy sources :** These resources are either mined or obtained from the environment, *e.g.*, *fossil fuels* (coal, lignite, natural gas, and oil etc.), *hydro energy* (thermal power, hydel power, nuclear power), *solar energy* (directly from the sun), *wind energy* (from moving air used by wind mills), *tidal energy* (associated with rise and fall of tidal waters).

The sources of primary energy available for our use have often been characterised as either ***renewable*** or ***non-renewable***. Putnam (1953) described these in terms of phrases ***energy income*** and ***energy capital***, respectively.

***(i) Energy income or renewable energy resources* :** They comprise those resources that are being continuously renewed because of the presence of tidal forces, wind, falling water, thermal gradients in the ocean, geothermal heat, direct solar input, the generation of animal and vegetable matter.

***(ii) Energy capital or non-renewable energy resources* :** These refer primarily to fossil fuels, which were deposited on earth hundreds of millions of years ago or to radioactive minerals which were present when the planet was formed. When such materials are mined, the quantity of non-renewable energy is reduced. Actually, the fossil fuels are being replaced in nature, but at a rate that is so slow on the time scale of human development as to be insignificant. So, oil, natural gas and coal can be considered non-renewable in the practical sense. The radioactive fuels uranium and thorium are not being replenished either. The currently available sources of primary energy are listed in Table-2.

Table-2. Available energy sources

Renewable sources (energy income)	Non-renewable sources (energy capital)
Solar input	Crude oil
Hydroelectric energy	Coal
Geothermal heat	Natural gas
Tidal forces	Synthetic oil (from oil sands and oil shales)
Wind	Nuclear fission
Biomass (wood, animal refuse, vegetable matter etc.)	
Ocean heat	

During the twentieth century, the annual consumption of primary energy provided comercially in the world has increased more than 10-fold as shown in figure (1), as per **World Energy Conference** (1986) and **British Petroleum** (1992) sources.

(b) Secondary energy resources : These sources do not occur in nature. They are derived from primary energy resources, *e.g.*, petrol (or gasoline), electrical energy from burning of coal, hydrogen gas obtained by the electrolysis of water.

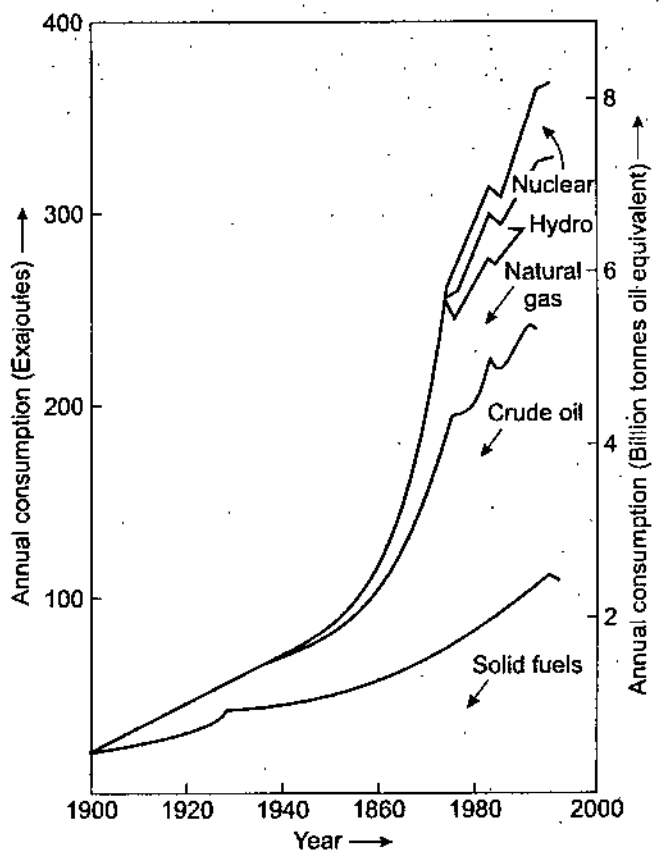


Fig. 1. World's primary energy consumption during 20th century.

[III] Alternate Energy Sources

(1) Hydropower Energy : The term hydropower often suggests giant dams capable of transmitting tens of thousands of cubic feet of water per minute. In India, most of the electricity demand is met by hydropower. Low head hydropower appears to have a promising future in less developed parts of the world. For example, China has more than 76,000 low head dams generating a total of 9,500 megawatts of power. An estimated 50 percent of rural townships depend on such plants to meet their electrical demands. Low head hydropower is also of increasing importance in nations with fossil fueled plants and growing electricity needs. Among the fastest growing of these are India, Peru, Thailand, Costa Rica and Guatemala.

Mini-hydel generation is more efficient than thermal generation and with less initial cost and short gestation period. It can be set up where sufficient water flows. It helps to accelerate the industrial and economic development of the area.

(2) Ocean Energy : For many years, scientists have been aware of one enormous reservoir of energy on the earth's surface, the oceans. As sunlight falls on the oceans, its energy is absorbed by seawater. The oceans are in one sense, therefore, a huge '*storage tank*' for solar energy. The practical problem is finding a way to extract that energy and make it available for human use.

The mechanism suggested for capturing heat stored in the ocean depends on a thermal gradient always present in seawater. Upper levels of the ocean may be as much as 20°C warmer than regions 1 km deeper. The technology of **Ocean Thermal Energy Conversion** (OTEC) takes advantage of this temperature gradient.

An OTEC plant would consist of a very large floating platform with pipes at least 100 feet (30 m) in diameter reaching to a depth of upto 1 km. The working fluid in such a plant would be ammonia, propane or some other liquid with a low boiling point.

Warm surface waters would be pumped into upper levels of the plant, causing the working fluid to evaporate. As the fluid evaporates, it will also exert increased pressure. That

pressure can be used to drive a turbine, that, in turn, generates electricity. The electricity could be carried to shore along large cables or used directly on the OTEC plant to desalinise water, electrolyse water or produce other chemical changes.

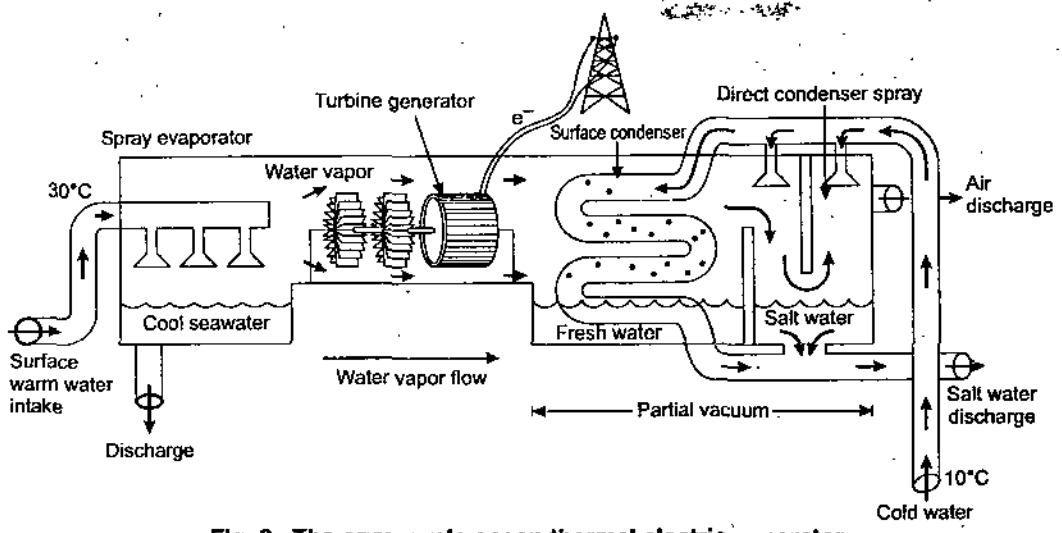


Fig. 2. The open cycle ocean thermal electric generator.

In the second stage of operation, cold water from deeper levels of the ocean would be brought to the surface and used to cool the working fluid. Once liquified, the working fluid would be ready for a second turn of the generating cycle.

OTEC plants are alternative energy sources in regions near the equator, where surface temperatures may reach 25°C or more. These parts of the ocean are often adjacent to less developed countries, where energy needs are growing.

(i) Advantages of OTEC plants :

(a) Wherever they are located, OTEC plants have a number of advantages. For one thing, oceans cover nearly 70 percent of the planet's surface so that the raw material OTEC plants need—seawater—is readily available. The original energy source—sunlight—is also plentiful and free.

(b) OTEC plants are also environmentally attractive since they produce no pollution and cause no disruption of land resources.

(c) Planners suggest that a by-product of OTEC plants might be nutrients brought up from deeper ocean levels and used to feed forms of fish or shellfish.

(ii) Disadvantages of OTEC plants :

(a) The most important disadvantage is the enormous cost of building and maintaining the mammoth structures needed for an OTEC plant.

(b) The temperature differential available under even the best of conditions means that an OTEC plant will not be more than about 3 percent efficient. The low efficiency of OTEC means that this technology will never be able to compete economically with other alternate sources of energy.

(3) Wind Energy : When energy experts look for alternative energy sources, they often search for new ways to use solar energy and one of the most obvious of these is harnessing wind power.

When sunlight strikes the earth, it heats objects such as land, water and plants but it heats them differentially. Dark coloured objects absorb more heat than light coloured ones and rough surfaces absorb more heat than smooth ones. As these materials absorb more or less heat, they also transmit that to the air above them. When air is warmed, it rises and is replaced by cooler air and this movement of air results in winds. So, some geographic regions are more likely to experience windy conditions than others and from the standpoint of energy production, these areas are reserves from which solar energy can be extracted.

Devices used for capturing the energy of winds are known as ***windmills***. The wind strikes the blades of a windmill, causing them to turn, and the solar energy stored in wind is

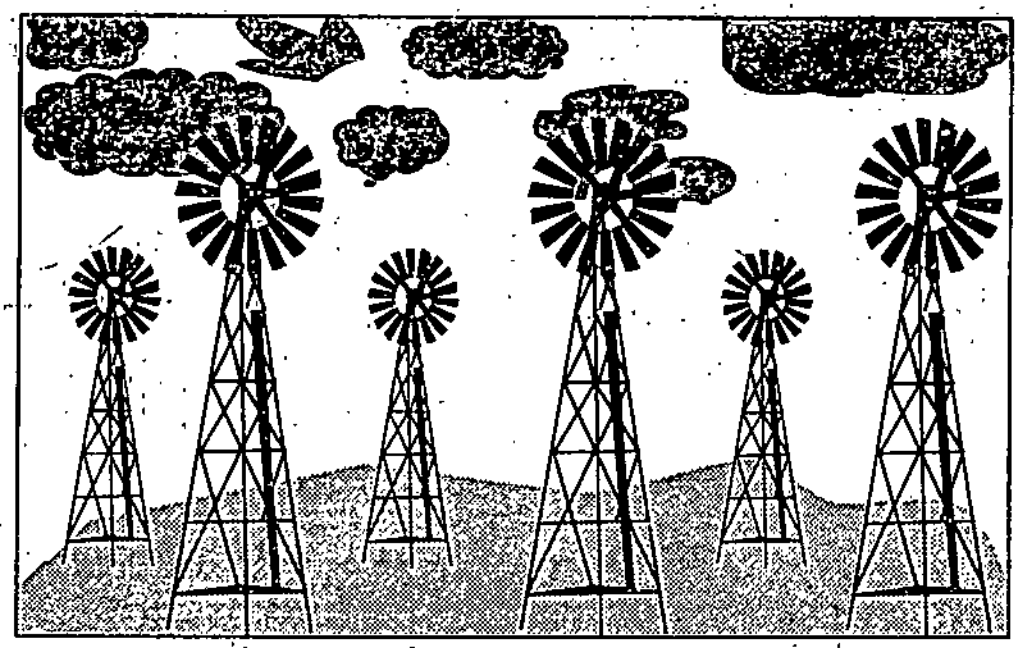


Fig. 3. Wind turbine.

converted to the kinetic energy of moving blades. That energy, in turn, is used to turn an axle, to power a pump, to run a mill or to perform some other function. The amount of power that can be converted by a windmill deperds primarily on two factors, *viz.*, the area swept out by the windmill blade and the wind speed. One goal in windmill design, is to produce a machine with very large blades. But the power generated by a windmill depends on the cube of the windspeed and so in any operating natural wind patterns are by far the most important considerations.

(i) Advantages of wind energy :

(a) Farmers have been using windmills to draw water from wells and to operate machinery for centuries. It is also to generate electricity on a small scale. During the 1970s, both governmental agencies and private organisations stepped up their research on wind power. The **National Aeronautics and Space Administration** (NASA), for example, designed a number of windmills ranging from designs with huge, broad-blade fans to ones with thin, airplane-like propellers. The largest of these windmills can generate 2.5 megawatts of electricity.

As a result of changing economic conditions and technological advances, windmills became an increasingly popular energy source for both individual homes and large energy producing corporation. 'Windfarms' consisting of hundreds of individual windmills are able to generate enough electricity to meet the needs of small communities. The greatest number of windfarms are found in California and the greatest concentration of them are located at Altamont Pass, east of San Francisco. In 1993, a single company U.S. Windpower generated 420 megawatts of electricity by operating 4,200 windmills at Altamont Pass. The company was recently retained by the Ukrainian government to construct a 500 megawatt wind farm to replace the power lost after the destruction of the **Chernobyl Nuclear Power Station** in 1986.

(b) The electricity generated by windmills could be sent back to land on large cables or used on the platforms to generate hydrogen from seawater, which could then be shipped to land and used as a fuel.

(ii) Disadvantages of wind energy :

(a) The obvious disadvantage is that wind energy can be used only in locations that have enough wind over an extended part of the day.

(b) Storage of energy is also a problem.

(c) Windfarms spoil the natural beauty of an area.

(d) They produce noise and create electromagnetic fields.

In India, recently a company named *Suzlon Energy* has constructed windmills.

(4) Solar Energy : The sun is a powerful fusion reactor, where hydrogen atoms fuse to form helium and give off a tremendous amount of energy. The surface of the sun, also known as *photosphere* has a temperature of 6000 K. The power emitted by the sun is 3.9×10^{26} watts.

Only a very small fraction of the sun's radiant energy reaches the earth's atmosphere and only about half of that reaches the surface of the earth. The other half is either reflected back into space by clouds or ice or is absorbed or scattered by molecules within the atmosphere. The sun's energy travels 93×10^6 miles to reach the earth's surface. It arrives in about 8·5 minutes after leaving the photosphere in different forms of radiant energy with different wavelengths, known as *electromagnetic spectrum*.

(i) Uses of solar energy :

The solar energy that reaches the surface of the earth and enters the biological cycle through photosynthesis is responsible for all forms of life, as well as all deposits of fossil fuel. All energy on earth comes from the sun and it can be used directly or indirectly. Direct uses include passive solar systems such as greenhouses and atriums, as well as hydropower, windmills and the burning of biomass. Indirect uses of solar energy include photovoltaic cells in which semiconductor crystals (mainly silicon, with small amounts of gallium arsenide or cadmium sulphide) convert sunlight directly into electrical power, and a process that produces methyl alcohol from plants.

Solar cells are connected in a series and framed on a rigid background. These modules are used to charge storage batteries aboard boats, operate lighthouses and supply power for emergency telephones on highways. They are also used in remote areas not connected to a power supply grid for pumping either for cattle or irrigation.

(ii) Advantages of solar energy :

The solar systems can be installed without much technical knowledge. They do not produce air pollution and have very low environmental impact. The operative maintenance is also very low.

(5) Tidal Power : In looking for alternative energy sources to meet future needs, some common physical phenomena are obvious candidates. One of these is ***tidal power.*** Twice each day on every coastline in the world, bodies of water are pulled onto and off of the shore as a result of gravitational forces exerted by the moon and sun. Only on ocean coasts is this change large enough to notice, however, and, therefore, to take advantage of as energy source.

The potential of tidal power as an energy source is clearly seen. Pieces of wood are carried onto a beach and then off again every time the tide comes in or goes out. In theory, the energy that moves this wood could also push against a turbine blade and turn a generator. In fact, the number of places on the earth where tides are strong enough to spin a turbine is relatively small.

One of the few commercial tidal power stations in operation is located at the mouth of La Rance River in France. Tides at this location reach a maximum of 13.5 metres. Each time the tide comes in, a dam at the La Rance station holds water back until it reaches its maximum depth. At that point, gates in the dam are opened and water is forced to flow into the river, driving a turbine and generator in the process. Gates in the dam are then closed, trapping the water inside the dam. At low tide, the gates open once again, allowing water to flow out of the river, back into the ocean. Again the power of moving water is used to drive a turbine and generator. So, the plant produces electricity only four times each day, during each of two high tides and each of two low tides. The plant's 25 percent efficiency rate is about equal to that of a power plant operated on fossil fuels.

Drawbacks of tidal power plants : The cost of building tidal power plants is significantly greater than the cost of building conventional power plants of similar capacity.

Still, optimists believe that serious development of tidal power could provide up to a third of the electrical energy now obtained from hydropower worldwide at some time in the future.

Despite the drawbacks and expense of tidal power, China is one country that has used it extensively since energy needs are often modest in China, low capacity plants are more feasible. As of the late 1980s, therefore, the Chinese had built more than 120 tidal power plants to provide electricity for small local regions.

(6) Fossil Fuels : In early societies, wood or other biological fuels were the main energy source. Today in many non-industrial societies, they continue to be used widely. Biological fuels may be seen as part of a solar economy where energy is extracted from the sun in a way that makes them renewable. However, industrialisation requires energy sources at much higher density and these have generally been met through the use of fossil fuels such as coal, gas or oil. These represent the principal source of energy for most of the industrialized world. Coal, oil and natural gas provide over 85 percent of the total primary energy used around the world.

Disadvantages : Coal is often seen to be the most polluting fuel because low grade coals can contain large quantities of ash, sulphur and chlorine. High rank coals such as anthracite have a high carbon content. Coal is sometimes converted to coke or other refined products such as **coalite**, a smokeless coal. These derivatives are less polluting. One of the principal concerns about the current reliance on fossil fuels relates not so much to their limited supply, but more to the fact that combustion releases such large amounts of carbon dioxide. Our use of fossil fuels over the last century has increased the concentration of carbon dioxide in the atmosphere. There is mounting evidence that this has increased the temperature of the earth through an enhanced ***greenhouse effect.***

(7) Biomass Fuel : *A biomass fuel is an energy source derived from living organisms.* Most commonly, it is a plant residue, harvested dried and burned or further processed into solid, liquid or gaseous fuels. The most familiar and widely used biomass fuel is wood. Agricultural waste, including materials such as the cereal straw, seed hulls, corn stalks and cobs is also a significant source. Native shrubs and herbaceous plants are potential sources. Animal waste although much less abundant overall is a bountiful source in some areas. Globally, it is estimated that biomass supplies about 6 or 7 percent of total energy and it continues to be a very important energy source for many developing countries. Because biomass is a potentially **renewable resource,** it is recognised as a possible replacement of petroleum and natural gas.

Biomass is not as concentrated an energy source as most fossil fuels even when it is thoroughly dry. Its density may be increased by milling and compressing dried residues. Solid fuels are not as convenient or versatile as liquids and gases and this is a drawback to the direct use of biomass. Fortunately, a number of techniques are known for converting it to liquid or gaseous forms as discussed below.

(i) Partial combustion : In this procedure, biomass is burned in an environment with restricted oxygen. Carbon monoxide and hydrogen are formed instead of carbon dioxide and water. This mixture is called **synthetic gas** or **syngas.** It can serve as fuel although its energy content is lower than natural gas (methane). Syngas may also be converted into methanol that can be used as a transportation fuel. Because methanol is a liquid, it is easy to store and transport.

(ii) Anaerobic digestion : It is another method for forming gases from biomass. It uses micro-organisms, in the absence of oxygen to convert organic materials to methane. This method is particularly suitable for animal and human waste. Animal feedlots faced with disposal problems may instal microbial gasifiers to convert waste to gaseous fuel used to heat farm buildings or generate electricity.

(iii) Fermentation : Through acid hydrolysis or enzymatic digestion, starch can be extracted and converted to sugars. Sugars can be fermented to produce ethanol, a liquid biofuel with many potential uses.

Biomass derived gaseous and liquid fuels share many of the same characteristics as their fossil fuel counterparts. Once formed, they can be substituted in whole or in part for

petroleum derived products. Gasohol, a mixture of 10 percent ethanol in gasoline is an example.

(8) Biogas Energy : Biogas is used as an alternative source of energy in some third world countries. It is produced in digester units by the anaerobic decomposition of organic wastes such as manures and crop residues. Beneficial by-products of biogas production includes sludges that can be used to fertilize and improve soil and the inactivation of pathogens in the waste. In addition, there is ongoing research on using organic wastes in developing countries :

(i) in fish farming

(ii) to produce algae for human and animal consumption, fertilizer and other uses.

(iii) to produce aquatic macrophytes for animal feed supplements.

(9) Energy from Plant Wastes : Wood, green plant matter, straw, rice bran, saw dust etc. constitute plant wastes. A rice straw fired thermal plant was inaugurated at Jalkheri (Punjab) at a cost of Rupees 35 crores. This will generate nearly 65 millions units of electricity per annum. It is the only plant of its kind in the world. Since 1988, **Central Mechanical Engineering and Research Institute, Durgapur** has run India's first pilot plant using solid garbage (leafy wastes) to generate electricity.

• 1.12. LAND RESOURCES

[I] Land as a Resource

Land is any part of the earth's surface that can be owned as property. Land comprises a particular segment of the earth's crust and can be defined in specific terms. The location of the land is extremely important in determining land use and land value. India has a total area of 329 million hectares. The utilization statistics is available only for nearly 92.5 percent of the total area. The area of agricultural land is about 162 million hectares. Nearly 5 percent of the land is fallow. As per the pictures sent by satellites, nearly 46 million hectares is under forest cultivation. A part of the land not in use includes arid, rocky and sandy deserts. Land is limited in supply and as our population increases we have less land to support each person. Land nurtures the plants and animals that provide our food and shelter. It is the watershed or reservoir for our water supply. Land provides the minerals we use, the space on which we build our homes and the site of many recreational activities. Land is also the depository for much of the waste created by modern society. The growth of human population only provides a partial explanation for the increased pressure on land resources. Economic development and a rise in the standard of living have brought about more demands for the products of the land. This demand now threatens to erode the land resource.

[II] Degradation of Land

Land characteristics and ownership provides a basis for the many uses of land. Some land uses are classified as irreversible, for example, when the application of a particular land use changes the original character of the land to such an extent that reversal to its former use is impracticable. Reversible land uses do not change the soil cover or landform and the land manager has many options when overseeing reversible land uses.

Many types of land require special types of zoning. For example, coastal areas are environmentally vulnerable to storms, high tides, flooding and strong winds. The coastal land should be protected. Areas with special scenic, historic or recreational value have long been protected. Special land use control should be exercised so that the land is not degraded and is used for purposes which serve the society.

[III] Man Induced Landslides

Landslide is a general term for the discrete downslope movement of rock and soil masses under gravitational influence along a failure zone. The term **'landslide'** can refer to the resulting land form, as well as to the process of movement. Many types of landslides occur and they are classified by several schemes, according to a variety of criteria.

Landslides are categorised most commonly on the basis of geometric form but also by size, shape, rate of movement and water content or fluidity. Translational or planar failures such as debris avalanches and earth flows, slide along a fairly straight failure surface which runs approximately parallel to the ground surface. Rotational failures, such as rotational slumps, slide along a spoon shaped failure surface, leaving a hummocky appearance on the landscape. Rotational slumps commonly transform into earthflows as they continue downslope. Landslides are usually triggered by heavy rain or melting snow, but major earthquakes can also cause landslides. Man made deforestation is also one of the reasons of landslides.

[IV] Soil Erosion

The natural movement of soil particles by wind or water from one location to another is called soil erosion. Uncontrolled soil erosion is a significant environmental problem. Soils in agricultural regions are a precious natural resource and the loss of these fertile soils from unwise land-use practices can be devastating. One of the most notable examples of this is the ***Oklahoma Dust Bowl*** of the 1930s. When a prolonged drought hit Oklahoma after many years of decreasing soil fertility, strong summer winds literally blew the dry topsoil away. In addition to environmental damage, this caused severe economic hardship and social dislocation.

Not all problems related to soil erosion are as dramatic as the Oklahoma Dust Bowl, but the cumulative effect of less extensive erosion episodes can still have adverse environmental effects, particularly with respect to water quality. Soil erosion has been identified as one of the most significant sources of water pollutants.

Soil particles suspended in water interfere with the penetration of sunlight. This in turn reduces photosynthetic activity of aquatic plants and algae, disrupting the ecological balance of the stream. When the water velocity decreases, the suspended particles settle out and are deposited as **sediment** at the bottom of the stream or lake. Sediment smothers *benthic* or bottom dwelling, organisms and disrupts the reproductive cycles of fish and other life forms.

(1) Types of soil erosion : There are two types of water caused soil erosion (a) ***sheet erosion*** from land areas by raindrop impact and overland flow of storm run-off and (b) ***stream erosion*** or the removal of soils from stream beds and stream banks by the swiftly moving channelised water.

(2) Factors affecting soil erosion : The factors that affect the rate of sheet erosion include rainfall intensity, soil texture, steepness of slope and amount of vegetative cover. The velocity of streamflow is one of the most important factors in stream erosion, although the type of soil is important too. The quantity of erosed material carried by some of the larger streams and rivers can be enormous. A natural vegetative cover of grass and trees provides protection against sheet erosion. Land use activities such as agriculture and construction which temporarily remove the natural vegetation and expose the bare soils are the main causes of serious erosion and sediment problems.

(3) Control of soil erosion : Soil erosion can be controlled by using the following methods.

(a) *Temporary grass cover* on exposed soils can be used to reduce wind and water erosion until permanent seeding or soil stabilisation is done. Application of lime and fertilization should be done on the basis of soil test data and the proper seed mixture should be applied.

(b) *Mulching materials* such as unrotted salt hay or woodchips can be used for temporary cover on areas difficult to vegetate because of steep slopes, unsuitable soils or winter operations.

(c) *Diversion channels* can be constructed across slopes to reduce open slope length, as shown in figure (4). These channels are constructed with a ridge on the lower side of the slope diverting water to sites where it can be disposed off safely. They may be temporary or permanent.

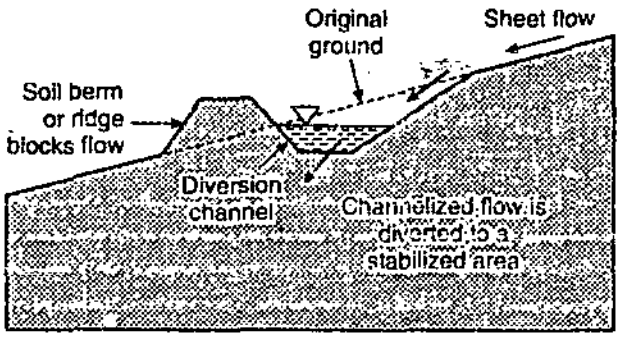


Fig. 4. Diversion channels.

(d) *Sediment basins* or *ponds* can be built to intercept and retain water carrying suspended soil particles. The sediment is deposited in the pond, protecting streams or drainage systems downstream of the construction site. These ponds can be temporary or permanent earth structures and may be designed to reduce peak storm flows and flooding.

(e) *Temporary fences*, as shown in figure (5) can be used to reduce erosion at construction sites. They are generally placed on the perimeter of the site at the lower elevations where water runs off.

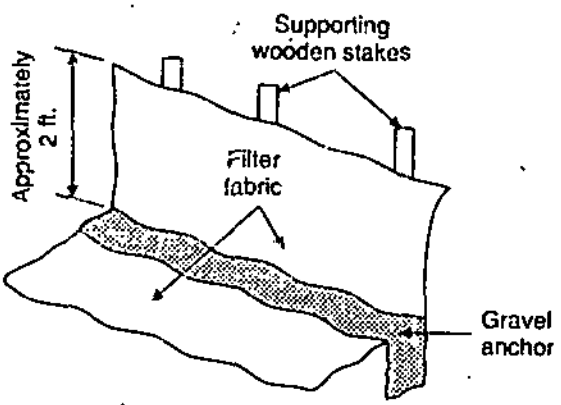


Fig. 5. A temporary fence can be constructed to control erosion at a construction site.

(f) *Hay bales* can be placed around storm water inlets or at the low point on the site to intercept sediment-laden run-off and prevent the soil from entering the storm drainage system. This is shown in figure (6).

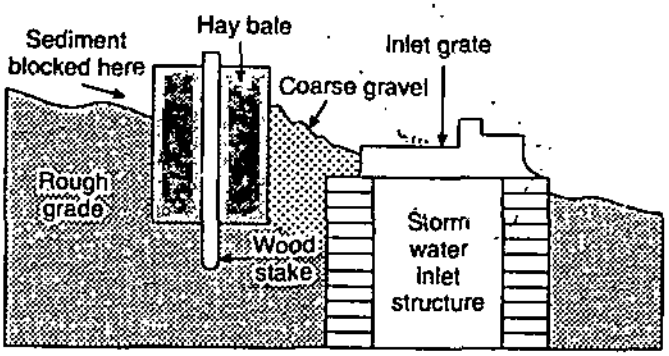


Fig. 6. A typical hay bale and gravel filter.

(g) *Scheduling of construction* can be done so as to minimise exposure of bare soils prior to final landscaping or paving. Drainage and soil protection facilities should be completed as early as possible.

(h) *Channel stabilisation* can be used to provide capacity in streams and drainage ditches for the flow of water without excessive erosion. Flow velocities should be minimised by the proper alignment and slope of the channel. Also, the channel can be protected by linings such as grass, concrete or stone riprap.

[V] Desertification

Almost one billion people live in arid or semi-arid desert lands that occupy about one-third of the world's land surface. In these drier parts of the world, deserts are increasing rapidly from a combination of natural processes and human activities, a process known as ***desertification*** or ***land degradation.*** An annual rainfall of less than 25 cms will produce a desert anywhere in the world. In the semi-arid areas along the desert margins, where the annual rainfall is around 40 cms, the ecosystem is inherently fragile with seasonal rains supporting the temporary growth of plants. Recent changes in the climate of these regions have meant that the rains are now unreliable and the lands that were once semi-arid are now becoming deserts. The process of desertification is precipitated by prolonged droughts, causing the top layers of the soil to dry out and blow away. The eroded soils become unstable and compacted and do not readily allow for seeding. This means that desertified areas do not regenerate by themselves but remain bare and continue to erode. Desertification of grazing lands or croplands is accompanied, therefore, by a sharp drop in the productivity of the land.

(1) Factors affecting desertification and effects : Natural desertification is greatly accelerated by human activities that leave soils vulnerable to erosion by wind and water. The drier grasslands with too little rain to support cultivated crops have traditionally been used for grazing livestock. When semi-arid land is *overgrazed* (by keeping too many animals on too little land), plants that could survive moderate grazing are uprooted and destroyed altogether. Since plant roots no longer bind the soil together, the exposed soil dries out and is blown away as dust. The destruction and removal of the topsoil means that soil productivity drops drastically. The obvious solution to desertification caused by overgrazing is to limit grazing to what the land can sustain.

Other factors leading to desertification include over-cultivation, deforestation, salting of the soil through irrigation and the ploughing of the marginal land. These destructive practices are intensified in developing countries rapid population growth, high population density, poverty and poor land management. The consequences of desertification in some countries mean intensified drought and famine and lowered standards of living.

In marginal areas throughout the world, traditional farming practices can lead to desertification. Ploughing turns the top layer of the soil upside down, burying and killing weeds but exposing bare soil to erosion. In arid areas, the exposed soil dries out rapidly and is easily lost through wind erosion.

Deforestation results in more than just the loss of trees, for soil is eroded, nutrients are lost to the ecosystem, and the water cycle is disrupted. The roots of the trees serve to bind the soil together and to hold water in the ecosystem, while the leaves of the trees break the force of the rain and allow it to soak into the topsoil. The result is that surface run-off from a forested hillside is half as much as from a grass covered slope. Additionally, water soaking into the ground leads to the natural recharge of groundwater and other water resources. Water and soil run-off from deforested hillsides cause flooding and siltation of agricultural and aquatic ecosystems in adjacent lowlands. Clearing forests, therefore, exposes the soil to both erosion and nutrient loss and changes the recharge of water reserves in the ecosystem.

In Ethiopia, population and economic pressures pushed people to deforest and cultivate hillsides and marginally drylands and more than 1 billion tons of topsoil per year are now lost, resulting in recurrent famines.

In parts of India and Africa, there is so little wood available that dried animal dung is used to fuel cooking fires, an act that further robs the soil of potential nutrients. The answer to erosion from deforestation is reforestation, better forest conservation and better forest management to increase productivity.

Reforesting desertified areas first requires mulching the soil to hold moisture and the protection of the seedlings for several years until natural processes can regenerate the soil. Using these methods, Israel has achieved spectacular success in bringing desertlands (a product of past desertification) back to agriculture. Desertification and its agents, deforestation and erosion have been powerful shapers of human history. Agriculture had its roots in the once fertile crescent of the Middle East and in the Mediterranean lands. However,

deforestation, overgrazing and poor agricultural practices have turned once-productive pastureland and farmland into the near deserts of today. It is thought by some that deforestation and desertification may have even contributed to the collapse of the Greek and Roman Empires. Similar fates may have befallen the Harappan Civilization in India's Indus Valley, in what is today desertland.

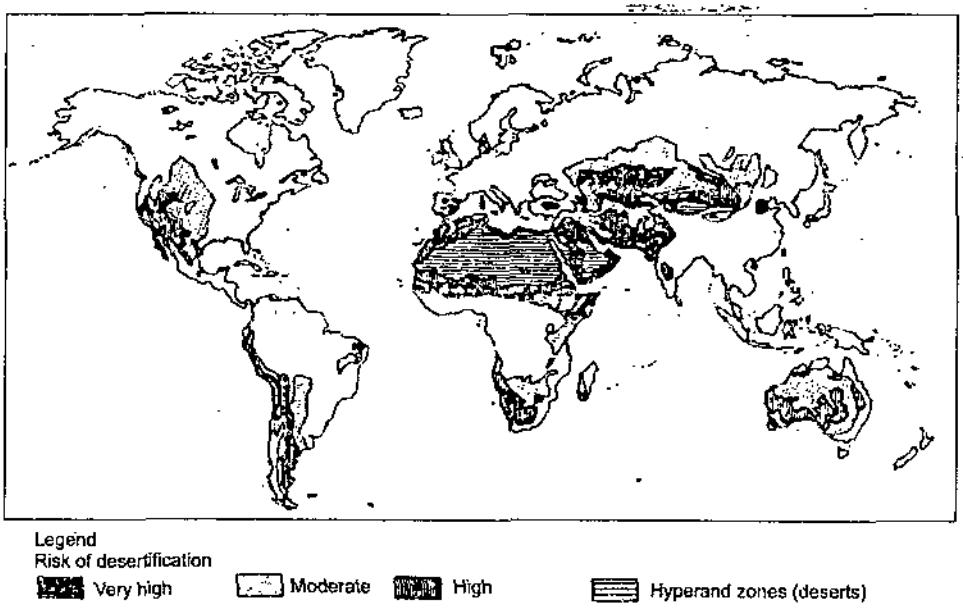


Fig. 7. World deserts and areas at risk of desertification.

Role of an Individual in Conservation of Natural Resources : Natural resources, unlike man-made resources, exist independently of human labour. Natural resources can be viewed as an endowment or a gift to human kind. These resources are, however, not unlimited and must be used with care. Some natural resources are called ***'fund resources'*** because they can be exhausted through use, like the burning of fossil fuels. Other fund resources, such as metals can be dissipated or wasted if they are discarded instead of being reused or recycled. Some natural resources can be used up like fund resources, but they can renew themselves if they are not completely destroyed. Examples of the latter would include the soil, forest and fisheries.

The three most important causes for global environmental problems today are ***population growth, excessive resource consumption*** and ***high levels of pollution.*** All of these threaten the natural resource base. So, the role of an individual is to conserve the natural resources by putting a ban or control on the above mentioned factors.

• SUMMARY

- Natural resources unlike man made resources are forests, wetlands, wild life, mangroves etc.
- Forest means a plant community which predominantly consists of trees and other vegetation usually with a closed canopy.
- There are six types of forests, *viz.*, moist tropical, dry tropical, montane sub-tropical, montane temperature, subalpine and alpine scrub forests.
- Flood is a process when the water level in any stream, river, bay or lake rises above bank full.
- Drought is a situtation when the average annual rainfall is less than 75% of the normal rainfall and there is a shortage of surface or ground water affecting the plant and animal adversely.
- Dams are built to control flood hazards, to store water for irrigation and other uses or to produce electricity.

- Large variety of materials obtained from earth are called minerals. A nation's prosperity depends largely on its mineral resources.
- Metallic minerals are of metals like aluminium, gold, copper, silver, zinc etc.
- Non-metallic minerals are those which give products other than metals, *e.g.*, coal, oil, natural gas, sand, clay, soda ash etc.
- A fertilizer is a substance which is applied to land to increase the plant growth and produce higher crop yield.
- Most fertilizers contain different amounts of nitrogen, phosphorus, potassium, inorganic nutrients etc.
- Pesticides are chemicals which are used to kill insects, weeds and other organisms to protect humans, crops and livestock.
- Pesticides are of different types, *e.g.*, fungicides, herbicides, insecticides, rodenticides, antibiotics, etc.
- Besides the normal conventional sources of energy, there are alternate energy sources like hydropower energy, wind energy, ocean energy, solar energy, tidal energy, fossil fuels, biomass fuels, energy from plant wastes etc.
- Soil erosion is the natural movement of soil particles by wind or water from one location to another.

Student Activity

1. Define environment and environmental pollution.

2. What do you understand by alternate sources of energy?

3. What is the use of fertilizers?

4. How is soil eroded? Explain.

5. What do you understand by the term OTEC?

• TEST YOURSELF

Answer the following questions :

1. Define environment. Discuss its scope and importance.
2. *Define environmental pollution. Mention the factors affecting it.*
3. Explain the need for public awareness about environment.
4. Define the following terms :
   (i) Deforestation (ii) Floods
   (iii) Drought (iv) Water-logging
   (v) Renewable energy sources (vi) Non-renewable energy sources
   (vii) Soil erosion (viii) Desertification
   (ix) Landslide (x) Salinity of soil
   (xi) Overgrazing
5. Explain the benefits and the problems arising out from the construction of dams.
6. Explain with examples the renewable and non-renewable sources of energy.
7. *Write short notes on the following :*
   (i) Ocean energy (ii) Wind energy
   (iii) Solar energy (iv) Fossil fuels
   (v) Biomass (vi) Biogas
   (vii) Landslides (viii) Desertification
8. What do you understand by land degradation? Mention the effects due to land *degradation.*
9. What is water-logging? What are its effects on environment?
10. Explain the terms fertilizer and pesticide.
11. Discuss briefly the impact of over-utilization of water on ground and surface water.
12. Discuss the environmental effects of extracting and using mineral resources.
13. What is soil erosion? Explain the mechanism of soil erosion and mention the factors affecting it.
14. Write notes on the following :
   (i) Pesticide accidents (ii) Land degradation
   (iii) Alternate energy sources (iv) Timber extraction
   (v) Appiko movement (vi) Chipko andolan movement
15. What are the advantages and drawbacks of wind energy?
16. What can farmers do to increase agricultural products without increasing land use?
17. What are the alternative energy resources?
18. Differentiate between renewable and non-renewable natural resources.
19. *Discuss the energy scenario in Indian context.*
20. Write a note on world food problem.
21. What do you mean by deforestation? Explain its causes and ill effects.
22. Name and discuss the two major world food problems.
23. Explain the terms flood and drought. Mention some measures to control them.
24. How pesticides endanger the life of man, animals, micro-organisms and aquatic biota?
25. Write a note on OTEC technology.
26. What is the difference between drought, earthquake and flash floods?

27. Discuss the measures to control drought.

28. With the help of neat sketch discuss the structure of atmosphere along with temperature, profile of atmosphere and related phenomenon.

29. What are the different types of minerals? Describe the effects of mineral extraction on environment.

30. What is geothermal energy? Descibss its merits and limitations.

31. Dam is constructed to :
    (i) Protect manlife (ii) Produce energy
    (iii) Erode soil (iv) Protect landslide

32. Pesticide which kill weedy plants is known as :
    (i) Fungicides (ii) Rodenticides
    (iii) Herbicides (iv) Insecticides

33. Bacteria is a :
    (i) Biological pesticide (ii) Rodenticide
    (iii) Organic pesticide (iv) Antibiotic

34. Forests which have trees like sal, sandalwood, teak are called :
    (i) Hill forests (ii) Evergreen forests
    (iii) Deciduous forests (iv) Littoral forests

35. Fill in the blanks :
    (a) Water that flows on the surface of the land is known as ..... run off.
    (b) Forest which consists of shrubs and small trees and found at a height of 2800–3500 m is known as ..... forest.
    (c) Lack of sufficient rains is the cause of ..... .
    (d) Urea is an important ..... .
    (e) Chlorinated hydrocarbons is an example of ..... pesticide.
    (f) Afforestation carried out to the maximum is one of the measures to control .....

ANSWERS

31. (ii), **32.** (iii), **33.** (i), **34.** (iii),
35. **(a)** surface **(b)** subalpine **(c)** drought **(d)** fertilizer **(e)** organic **(f)** drought

UNIT

2

ECOSYSTEMS, BIODIVERSITY AND ITS CONSERVATION

STRUCTURE

- Concept of an Ecosystem
- Ecological Succession
- Biodiversity
- Levels of Biodiversity
- Value of Biodiversity
- Endangered and Endemic Species
- Hot Spots of Biodiversity
- Energy Flow in the Ecosystem
- Different Ecosystems
- India as a Mega Diversity Nation
- Gradients of Biodiversity
- Threats to Biodiversity
  - Conservation of Biodiversity
  - Biodiversity at Global, National and Local Levels

❑ Summary

❑ Student Activity

LEARNING OBJECTIVES

After studying this chapter, you will learn about the ecosystem and energy flow in it, different types of ecosystems as well as ecological succession. You will also learn about biodiversity, its value and threats to it, hot spots of biodiversity and its conservation.

2.1. CONCEPT OF AN ECOSYSTEM

The term **ecosystem** was coined in 1935 by the Oxford ecologist Arthur Tansley to encompass the interactions among biotic and abiotic components of the environment at a given site. The *living and non-living components of an ecosystem are known as* **biotic** and **abiotic** components, respectively. Ecosystem was defined in its presently accepted form by Eugene Odum as, ***"any unit that includes all of the organisms, i.e., the community in a given area interacting with the physical environment so that a flow of energy leads to clearly defined trophic structure, biotic diversity and material cydes,* i. e., *exchange of materials between living and non-living parts, within the system"*** [Fig. (1)].

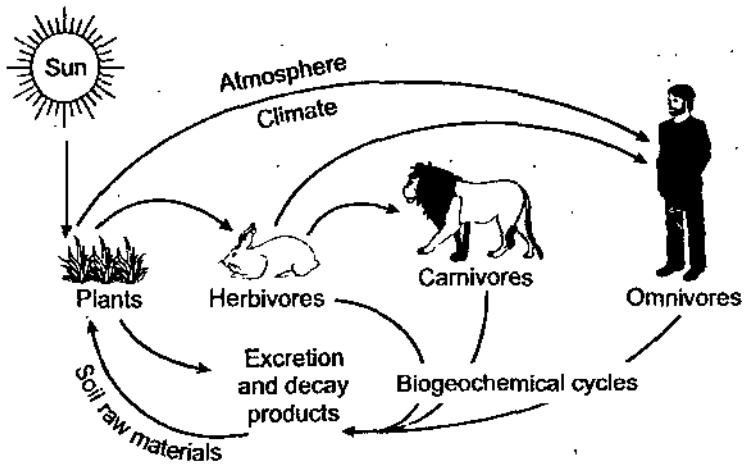


Fig. 1. Ecosystem : Generalized plan.

Tansley's cncept had been expressed earlier in 1913 by the Oxford geographer A.J. Herbertson, who suggested the term *macro-organism* for such a combined biotic and abiotic entity . He was, however, too far in advance of his time and the idea was not taken up by ecologists. On the other hand, Tansley's concept- elaborated in terms of the transfer of energy and matter across ecosystem boundaries-was utilised within the next few years by Evelyn Hutchinson, Raymond Lindeman and the Odum brothers, Eugene and Howard [(Fig. (2)].

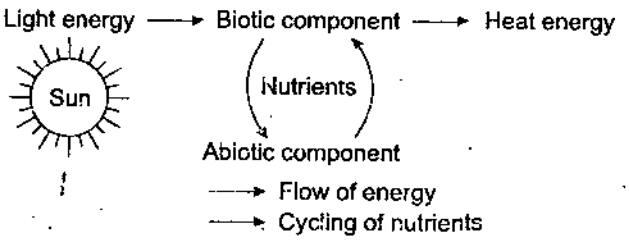


Fig. 2. Energy flow of cycling of matter in an ecosystem.

[I] Structure and Function of an Ecosystem

The two major aspects of an ecosystem are the *structure* and *function*. By **structure,** we mean :

(i) the composition of biological community including, numbers, species, life history, biomass and distribution in space etc.

(ii) the quantity and distribution of the non-living materials, *e.g.*, water, nutrients etc, and

(iii) the range or gradient of conditions of existence, *e.g.*, light, temperature etc.

By **function**, we mean :

(i) the rate of biological energy flow, *i.e.*, the production and respiration rates of the community.

(ii) rate of materials or nutrient cycles, and

(iii) ecological or biological regulation including regulation of organisms by environment (photoperiodism etc.) and regulation of environment by the organism (nitrogen fixing organisms etc.).

So, in any ecosystem, the structure and function are studied side by side.

(1) Structure of an Ecosystem : An ecosystem has two main components, *viz.*, abiotic and biotic components.

(I) Abiotic or non-living component **:** The abiotic or non-living component of the ecosystem is further subdivided into three parts:

(a) Inorganic substances **:** Different inorganic substances, *e.g.*, carbon, sulphur, nitrogen, hydrogen, phosphorus etc take part in material cycles. These are, therefore, always available to the ecosystem. The amount of these inorganic substances, present at any given time in an ecosystem is known as *standing state* or *standing quality.*

(b) Organic substances **:** The main organic substances which occur in the ecosystem include proteins, carbohydrates and lipids. Inorganic substances are taken in by the plants and are changed into organic substances during metabolism. These are added to the environment on the death of organisms. The organic materials then break down or decomposed to form inorganic substances and are made available to the plant. Therefore, the organic substances link biotic and abiotic components of the ecosystem.

(c) Climatic system **:** The entire ecosystem works under the influence of several environmental factors like light, rainfall, humidity, temperature etc.

(2) Biotic or living component **:** The biotic components of the ecosystem are collectively known as *community.* The biotic or living component is indeed the trophic structure of any ecosystem, where living organisms are distinguished on the basis of their nutritional relationship. From this trophic (nutrional) standpoint, an ecosystem is further sub-divided into two groups, *viz.*, *autotrophic organisms* called *producers* and *heterotrophic organisms* called *consumers.*

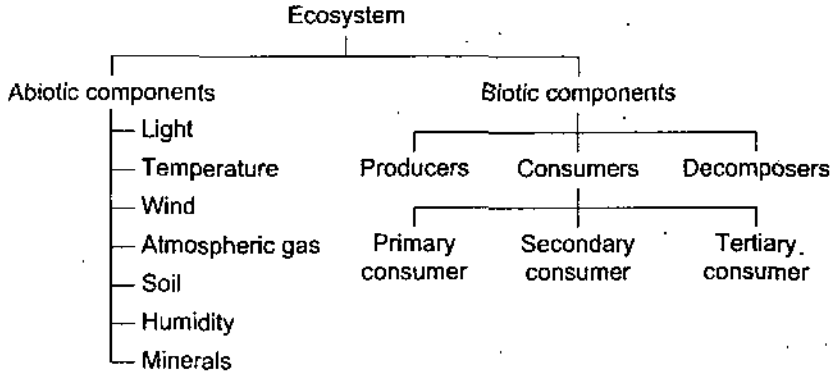
(a) Producers or autotrophic components **:** Producers are green plants which include prokaryotes like blue-green algae and bacteria. The producers are constituted mainly of green plants including photosynthetic bacteria. To some lesser extent, chemosynthetic microbes also contribute to the build up of organic matter. These substances serve as food for the other biotic components, *i.e.*, the heterotrophs.

(b) Consumers or heterotrophic components : The heterotrophic component cannot manufacture its own food material and, therefore, depends on substances synthesised by the producers. These are known as *consumers.* Consumers are further categorised as follows :

(i) Macroconsumers : These are the consumers, which in an order as they occur in a food chain are *herbivores, carnivores* (or *omnivores*). Herbivores are also called **primary consumers, secondary and tertiary consumers.** They all are phagotrophs which include mainly animals that ingest other organic and particulate organic matter.

(ii) Microconsumers : These are popularly known as **decomposers.** Organic material is added to the environment with the death of plants and animals and also due to the deposition of animal waste products. Such complex organic materials are decomposed by micro-organisms like bacteria, fungi, actinomycetes etc. and thus these organisms have been termed as **decomposers.**

The various abiotic and biotic components of an ecosystem can be summarised as follows :



(2) Functions of an Ecosystem : An ecosystem is a dynamic unit. It shows continuous interactions, *e.g.*, flow of energy, transfer of food etc [Fig. (3)]. The biotic and abiotic components of ecosystem are closely linked with one another to carry out these operations. All these processes are known as functions of an ecosystem. Following are some of the characteristic functions.

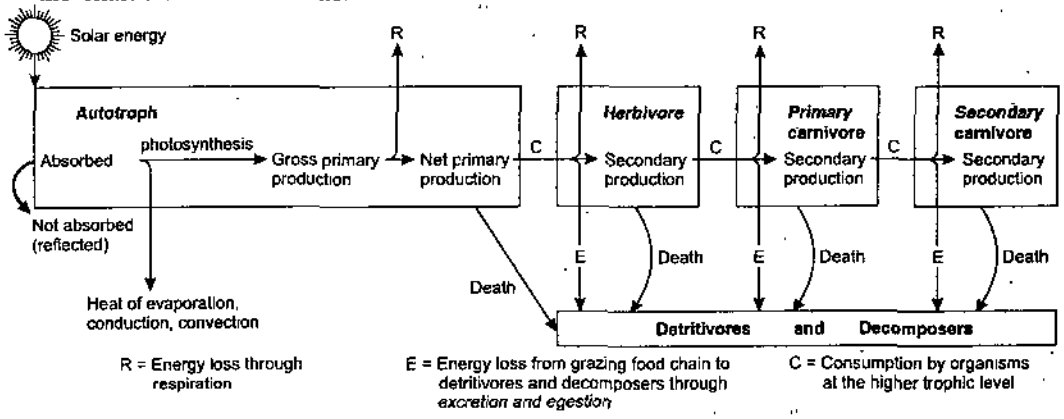


Fig. 3. Ecosystem : Flow of energy through different trophic levels of an ecosystem.

(1) Flow of energy : The producers, green plants fix energy from the sun and with the help of minerals (C, H, O, N, P, Ca, Mg, Fe, Zn etc) taken from their soil and aerial environment and build up complex organic matter, *viz*., carbohydrates, fats, proteins, nucleic acids etc. Some ecologists prefer to call the green plants as *converters* or *transducers*. The two ecological processes of energy flow and mineral cycling involving interaction between the physico-chemical environment and the biotic communities may be regarded as the **heart** of the ecosystem dynamics. According to figure (3), energy flows in non-cyclic way (uni-directional) from sun to the decomposers via producers and macroconsumers (herbivores

and carnivores), while the minerals keep on moving in a cyclic manner. The cycling of the minerals is carried out by different biogeochemical cycles super-imposed upon the uni-directional energy flow through the biotic component of the ecosystem. Some of the energy is lost to the environment when the branches, leavers etc of producers fall to the ground. These are broken down by the decomposers.

The flow of energy is from one trophic level to another. The amount of energy gradually decreases from the first trophic level to the last trophic level. The energy flow is represented as follows :

Sunlight ⟶ Producers ⟶ Herbivores ⟶ Carnivores ⟶ Decomposers.

Productivity of ecosystem : The productivity of an ecosystem refers to the rate of production, *i.e.*, the amount of organic matter accumulated in a unit time interval. Productivity is of following types :

(a) **Primary productivity :** It is defined as the *rate at which radiant energy is stored by photosynthetic and chemosynthetic activity of producers*. It is associated with the producers which are autotrophic, most of which are photosynthetic and to a much lesser extent the chemosynthetic micro- organisms. These are green plants, higher macrophytes as well as lower forms the phytoplanktons and some photosynthetic bacteria.

(b) **Secondary productivity :** It refers to the consumers or heterotrophs. *These are the rates of energy storage at consumer level.* As consumers only use food materials in their respiration, simply changing the food matter to different tissues by an overall process, secondary productivity is not classified as *gross* and *net amounts.* Secondary productivity actually keeps on moving from one organism to another, *i.e.*, remains mobile and does not live *in situ* like the primary productivity.

(c) **Net productivity :** This refers to the *rate of storage of organic matter not used by the heterotrophs (consumers), i.e.*, equivalent to net primary production minus consumption by the heterotrophs during the unit time, as a season or year etc. So, it is the rate of increase of biomass of the primary producers which has been left over by the consumers.

(2) Food chains : *The transfer of food energy from the producers through a series of organisms (herbivores → carnivores → decomposers) with repeated eating and being eaten is called a food chain.* Producers use the radiant energy of sun which is converted to chemical form, ATP during photo-synthesis. So, green plants occupy, in any food chain, the first trophic (nutritional) level-producers level and are known as **primary producers.** The energy which is stored in food matter made by green plants, is then used by the plant eaters—the herbivores, which constitute the second trophic level— the primary consumer level. These are called **primary consumers** (herbivores) or **consumers of the firxt order.** The herbivores in turn are eaten by the carnivores, which make the third trophic level-secondary consumer levels. These are called **secondary consumers** (carnivores) or **consumers of the second order.** These in turn may be eaten up by other carnivores at tertiary consumers level. These are called **tertiary consumers** or **consumers of the third order.** Some organisms are omnivores eating the producers and the carnivores at their lower level in the food chain. Such organisms may occupy more than one trophic levels in the food chain. This classification of all the living organisms of any ecosystem is one of their functions and not of species.

In any food chain, energy flows from primary producers to primary consumers (herbivores), from primary consumers to secondary consumers (carnivores) and from secondary consumers to tertiary consumers (carnivores/omnivores) and so on. **This simple chain of eating and being eaten up is called a food chain.** For example, a food chain in a pond ecosystem starts with phytoplanktons, going through water fleas, smaller fish, bigger fish, birds, larger animal and so on. Similarly, a food chain in grassland ecosystem starts with grasses and forbs and goes through grasshoppers, the frogs, the snake, the hawk (based on the food habits) and so on. Some of the common food chains are shown in figure (4).

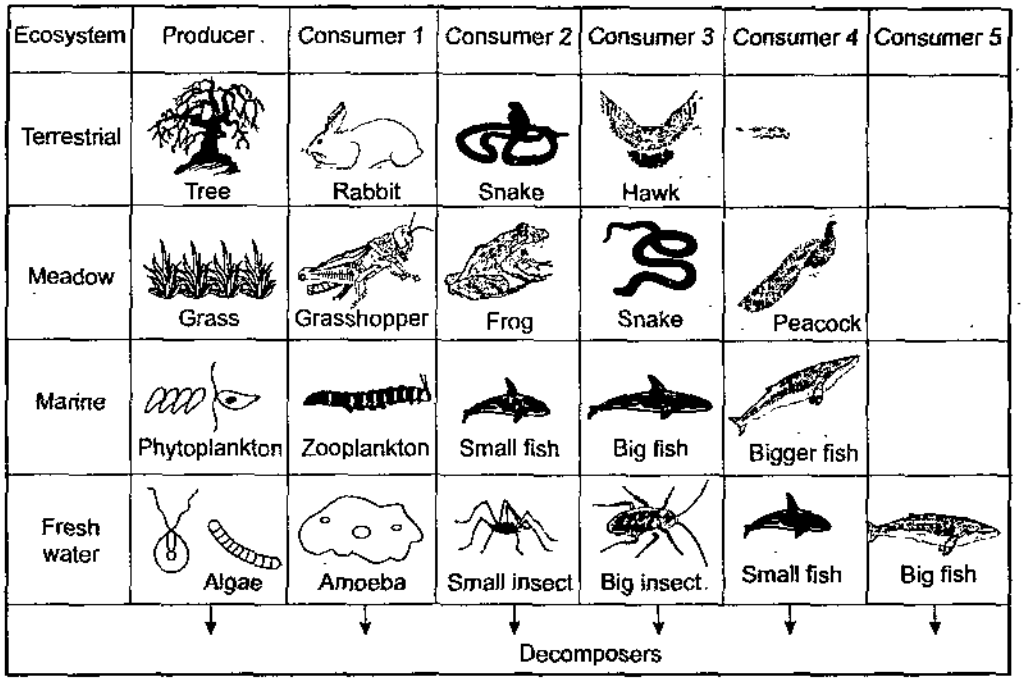


Fig. 4. Ecosystem : biotic components of food chains found in different ecosystems.

Types of Food Chains : There are two types of food chains, *viz.*, grazing and detritus food chains.

(a) *Grazing food chain* : This class of food chain starts from the living green plants, goes to grazing herbivores (that feed on living plant materials with their predators) and on to carnivores (animal eaters). Ecosystems with such type of food chain are directly dependent on an influx of solar radiation. So, this type of chain depends on autotrophic energy capture and the movement of this captured energy to herbivores. Mostly, ecosystems in nature follow this class of food chain. Examples of this type of food chain are (i) grasses-rabbit-fox and (ii) phytoplanktons- zooplanktons-fish sequences.

(b) *Detritus food chain* : This type of food chain goes from dead organic matter such as earthworms, fungi and bacteria into micro-organisms and then to organisms feeding on detritus (detritivores) and their predators. Therefore, such ecosystems are less depedent on direct solar energy. These depend mainly on the influx of organic matter produced in another system. For example, this type of food chain operates in the decomposing accumulated litter in a temperate forest. Heald (1969) and W.E. Odum (1970) showed that in the brackish zone of Southern Florida, leaves of the red mangrove—*rhizophore mangle*—fall into the warm, shallow waters : Only 5 percent of the leaf material was removed by grazing insects before leaf fall. As shown in figure (5), the fragments of the fallen leaf (acted on by Saprotrophs as bacteria, protozoa, fungi etc and colonised chiefly by phytoplanktonic and benthic algae) are eaten up and re-eaten by a group of small animals called detritus consumers and like crabs, grass shrimps, nematodes, amphipods, insect larvae etc. These detritivores animals are in turn eaten by some minnous and small game fish etc., *i.e.*, small carnivores which in turn serve as the main food for larger game fish and fish eating birds which are the large (top) carnivores. Detritus from seagrasses, saltmarsh grasses and seaweeds support fisheries-an important economy in that region in several estuarine areas.

(c) *Difference between grazing and detritus food chains* : We observe that the detritus food chain ends up in a manner similar to grazing food chain (big fish eat little fish), but the manner in which the two chains start is quite different. In figure (6), the detritus consumers in detritus chain, in contrast to grazing herbivores, are a mixed group in terms of trophic levels. These include herbivores, omnivores and primary carnivores. As a group, the detritus feeders get some of their energy directly from the plant material, most of it secondarily from micro-organisms and some tertiarily through carnivores, *e.g.*, by eating

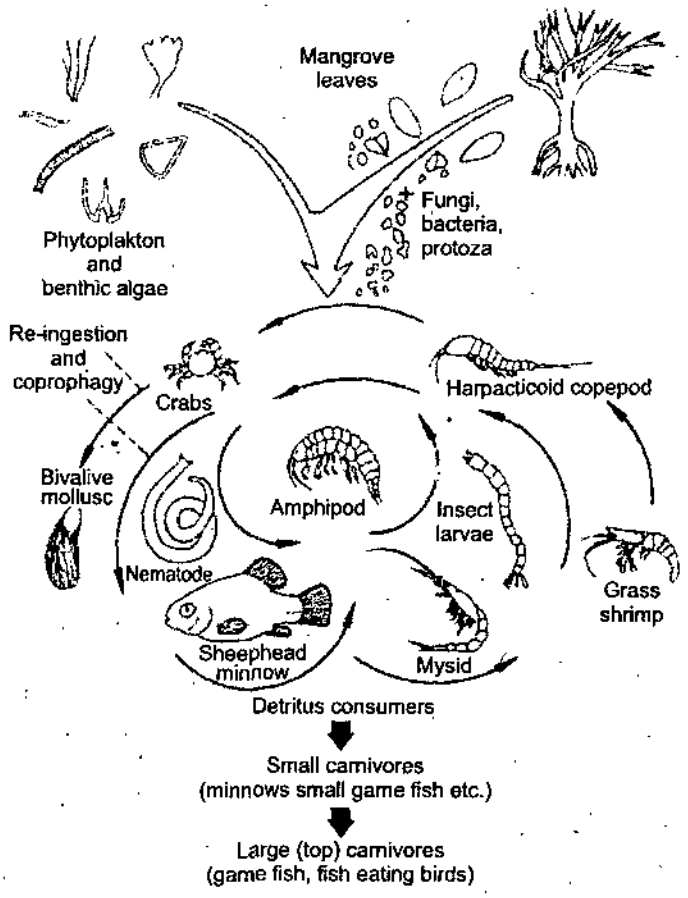


Fig. 5. Detritus food chain.

protozoa or other small invertebrates that have fed on bacteria that have digested plant material. Detritus food chain is simply a sub-component of another ecosystem.

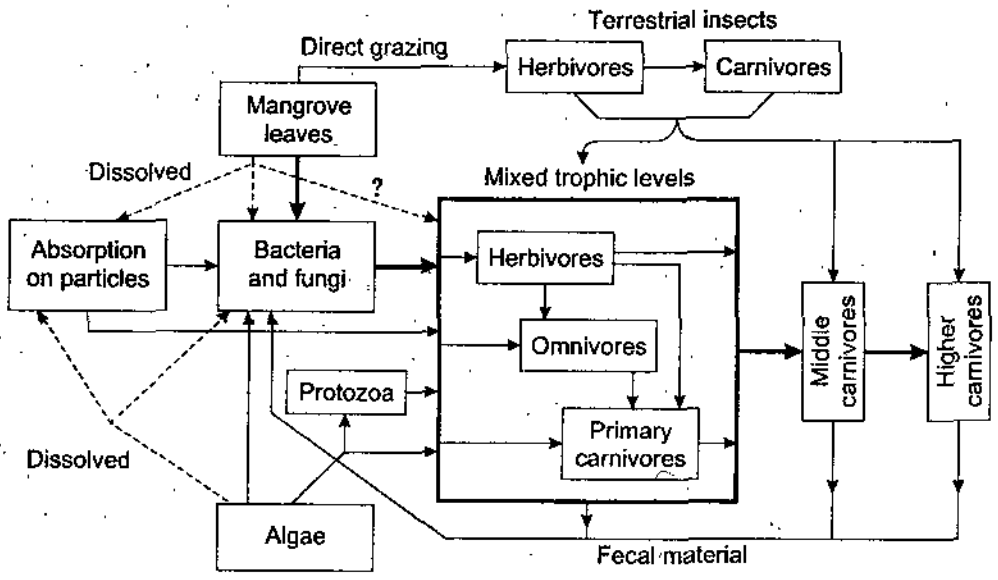


Fig. 6. A detritus food chain based on mangroves leaves falling into shallow estuary waters. Leaf fragments acted on by the saprotrophs and colonised by algae are eaten and re-eaten (coprophagy) by a key group of small detritivores which in turn, provide the main food for game fish, herons, storks and ibis.

(3) Food webs : In a food chain, one organism has a direct feeding relationship with another organism. In nature, however, the existence of a single food chain is not possible. The feeding relationships within an ecosystem are much more complex. The reason is that an

organism may feed on more than one organism in the same food chain or may feed on different food chains. In general, many food chains are interconnected in an ecosystem, as shown in figure (7). So, **a network formed by interconnecting food chains is known as a food web.**

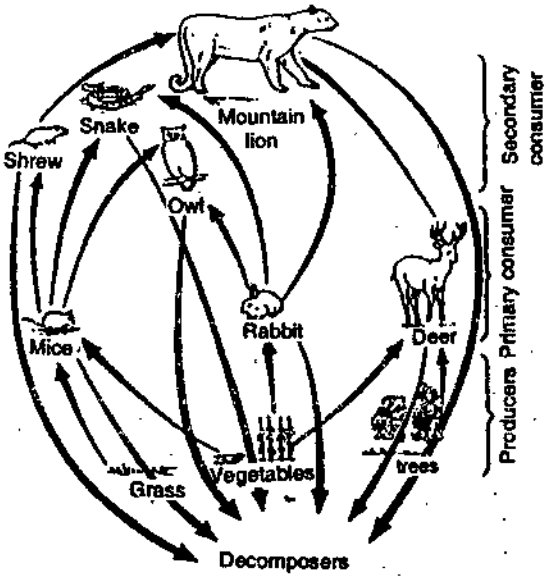


Fig. 7. Interconnection of an ecosystem.

In one ecosystem, rats feed upon plants, so also rabbits from other food chain feed upon plants. The rats could also be eaten up by other animals (other than the snake) and the snakes in turn could also be eaten up by hawks and peacocoks. In this manner, several food chains are interconnected with one another to form a food web.

Food web illustrates several alternative pathways. Food webs are very useful in maintaining stability of an ecosystem. If the number of rabbits in an area decreases, owls are expected to die of starvation. But due to decrease in the number of rabbits, more grass is left out that helps to increase the population of rats. Owls now feed upon rats and allow the rabbits to increase in number. Thus, the ecosystem does not get permanently disturbed when food web operates.

A balanced ecosystem is essential for the survival of all living organisms of the system (herbivores). If primary consumers in an ecosystem are absent, then producers increase in number causing overcrowding. This result in competition and, therefore, the number of consumers once again decreases to near normal. So, each species of any ecosystem maintains a balance because of natural checks present in the environment.

The complexity of any food web depends on the diversity of organisms in the system. Accordingly, it would depend on two main points.

(i) ***Length of the food chain*** **:** Diversity in the organisms based on their food habits would determine the length of food chain. More diverse the organisms in food habits, more longer would be the food chain.

(ii) ***Alternatives at different points of consumers in food chain*** **:** More the alternatives, more would be the interlocking pattern. In deep oceans, seas etc, where we find different types of organisms, the food webs are much complex.

(4) Ecological pyramids **:** The quantitative and the most easy method for studying the relationship between organisms in an ecosystem and for showing them diagrammatically, is the **ecological pyramid**, given by Elton (1927). In these figures, the lowermost trophic level is formed by the producers, while the topmost trophic level is that of carnivores. Generally, three types of pyramids are considered, *e.g.*, pyramid of numbers, pyramid of biomass and pyramid of energy.

(a) Pyramid of numbers **:** This pyramid illustrates the relationship between the number of producers, herbivores and carnivores. The organisms of an area are first counted

and then grouped into their trophic levels. The diagram shows largest number in the first trophic level of producers. The number shows gradual decrease from the second trophic level to the highest trophic level. We have studied three common ecosystems, *viz*., forest ecosystem, grassland ecosystem and pond ecosystem.

(i) *In forest ecosystem,* the shape of pyramid is rhomboidal [Fig. (8a)]. The producers are represented by a angle large tree, on which depend several fruit eating birds etc. Therefore, the number of primary consumers is more than the number of producers. Thereafter, the number of secondary and tertiary consumers decreases progressively.

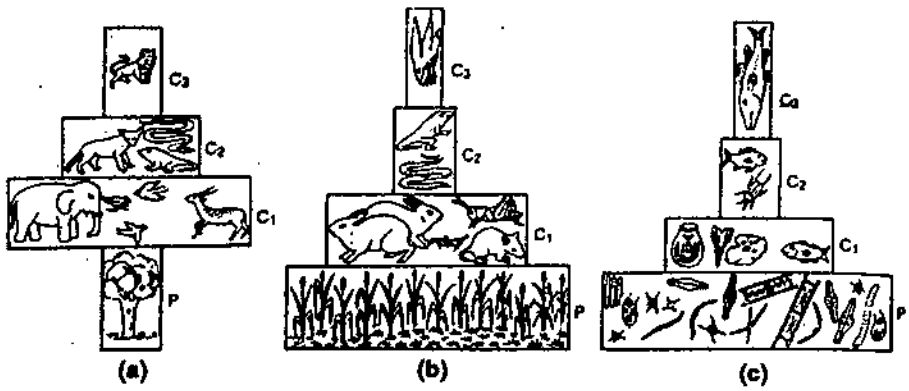


Fig. 8. Different types of pyramids in ecosystems : (C_1, C_2, C_3 = consumers of different tropic levels, P = producer).

(ii) *In grassland ecosystem,* grasses are the producers [Fig. (8b)]. These outnumber the organisms occurring in any trophic level of consumers. The number of consumers decreases towards the top of the pyramid. The number of primary consumers or herbivores like rats, rabbits etc, is lesser than the number of grasses. Tne number of secondary consumers like lizards, snakes etc., is lesser than the number of primary consumers. The number of last or tetriary consumers is still less than the number of secondary consumers. So, we see that the number of organisms falls progressively from the first trophic level to the last trophic lavel. Therefore, pyramid of numbers in grassland is straight or upright.

(iii) *In pond system,* the number of organism decreases progressively from the first trophic level to the last trophic level. Therefore, the pyramid of numbers in pond ecosystem is straigth upright [fig. (8c)].

(b) Pyramid of biomass : The total mass of organisms is called biomass. It can be determined in terms of net mass, dry mass or ash free dry weight. The biomass at the time of sampling is called ***standing biomass*** or ***standing crop biomass.***

In forest ecosystem [Fig. (9a)] and grassland ecosystem [Fig. (9b)], the pyramid of biomass is straight or upright. The amount of biomass continues to decrease progressively from the first trophic level of producers to the last trophic level of carnivores.

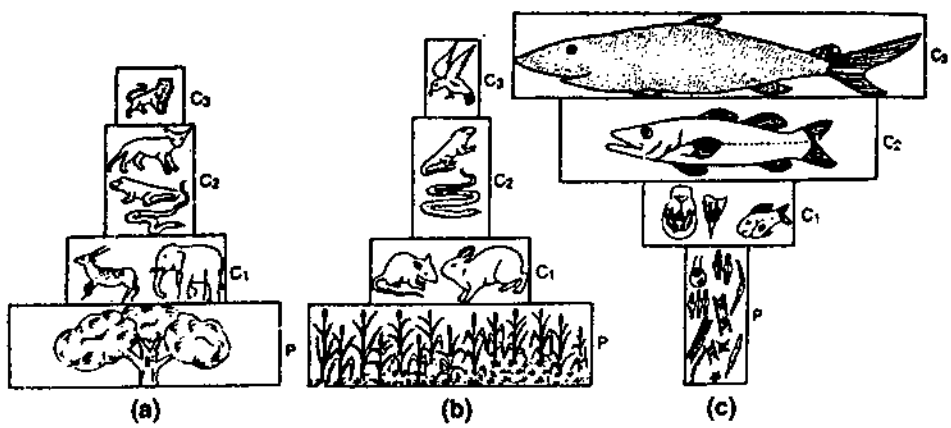


Fig. 9. Different types of pyramids in some ecosystems : (C_1, C_2, C_3 = consumers of different tropic levels, P = producer).

In pond ecosystem [Fig. (9c)], the number of producers (algae) is very large, but their biomass is the least of all, being very small in size. The amount of biomss continues to increase progressively with primary, secondary and tertiary trophic levels. Therefore, the pyramid of biomass in pond ecosystem is inverted.

(c) Pyramid of energy : The most ideal and fundamental method of representing the relationships between organisms in different trophic levels is the pyramid of energy.

We know that in every ecosystem, only producers possess the capacity to use the energy from the sun and convert it into food. The energy in the form of food gets transferred from one trophic level to another. Therefore, the ***flow of energy is always uni-directional***. The amount of energy that reaches the next trophic level is lesser than it was present in the earlier trophic level. Thus, the amount of energy decreases with each successive higher trophic level. Therefore, in all types of ecosystems, such a pyramid would be straight or upright, as shown in figure (10).

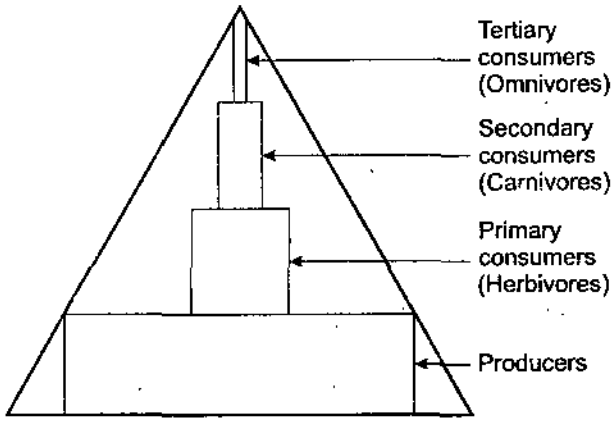


Fig. 10. Ecosystem : Pyramid of energy.

• 2.2. ENERGY FLOW IN THE ECOSYSTEM

The behaviour of energy in ecosystem in known as **energy flow** due to uni-directional flow of energy. In ecological energetics, we study :

(i) quantity of solar energy reaching an ecosystem.

(ii) quantity of energy used by green plants for photosynthesis, and

(iii) quantity and path of energy flow from producers to consumers.

So, from energetics point of view, it is necessary to understand for an ecosystem :

(i) the efficiency of the producers in absorption and conversion of solar energy.

(ii) the use of this converted chemical form of energy by the consumers.

(iii) the total input of energy in the form of food and its efficiency in assimilation.

(iv) the loss through heat, respiration, excretion etc, and

(v) the gross net production.

[I] Single Channel Energy Models

The principle of food chains and the working of the two laws of thermodynamics, can be understood clear from energy flow diagrams, shown in figures (11) and (12). As shown in figure (11), out of the total incoming solar radiation (118, 873 g cal/cm^2/year). 118, 761 g cal/cm^2/year remain unutilised and so gross production, *i.e.*, net production plus respiration, by autotrophs is 11 g cal/cm^2/year with an efficiency of energy capture of 0.10 percent. It may also be noted that 21 percent of this energy or 23 g cal/cm^2/year is consumed in metabolic reactions of autotrophs for their growth, maintenance, development and reproduction. It may also be observed that 15 g cal/cm^2/yr are consumed by herbivores that graze or feed on autotrophs which amounts to 17 percent of net autotroph production. Decomposition accounts for nearly 3.4 percent (3 g cal/cm^2/year) of net production. The remainder of the plant material, 79.5 percent of net production (70 g cal/cm^2/year) is not consumed at all but becomes part of the accumulating sediments. It is clear that much more energy is available for herbivory than is consumed. It may also be noted that different pathways of loss are equivalent to and account for total energy capture of the autotrophs, *i.e.*, gross production. Collectively, the three upper fates, *i.e.*, decomposition, herbivory and not utilised, are equivalent to net production. There is considerably more energy lost *via* respiration by herbivores (30 percent) than by autotrophs (21 percent). Again there is

considerable energy available for the carnivores, *viz.*, 70 percent with is not completely ued, in fact only 28.6 percent (3.0 g cal/cm^2/year) of net production passes to the carnivores. This is more efficient utilisations of resources than occurs at autotroph → herbivore transfer level. At the carnivore level nearly 60 percent of the carnivores energy intake is used in metabolic activity and the remainder becomes part of the not utilised sediments, whereas only a very small fraction is subject to decomposition yearly. This high respiratory loss compares with 30 percent by herbivores and 21 percent by autotrophs in this ecosystem.

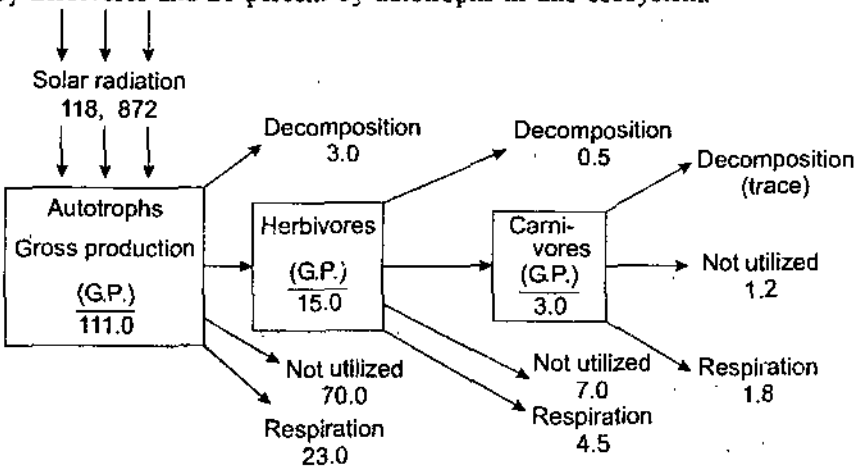


Fig. 11. Energy flow diagram for a lake (freshwater ecosystem) in g cal/cm^2/year.

Two things are clear from energy flow diagram, as shown in figure (11).

(i) There is one-way (uni-directional) street along which energy moves. The energy that is captured by autotrophs does not return to solar input, that which passes to the herbivores does not pass back to the autotrophs. As it moves progressively through the different trophic levels, it is no longer available to the previous level. Therefore, due to one-way flow of energy, the system would collapse, if the primary source (sun) were cut off.

(ii) There occurs a progressive decrease in energy level at each trophic level. This is mainly accounted by the energy dissipated as heat in metabolic activities and measured here as respiration coupled with unutilised energy.

In figure (12), the *boxes* represent the trophic levels and the *pipes* show the energy flow in and out of each level. Energy inflows balance outflows as required by the first law of

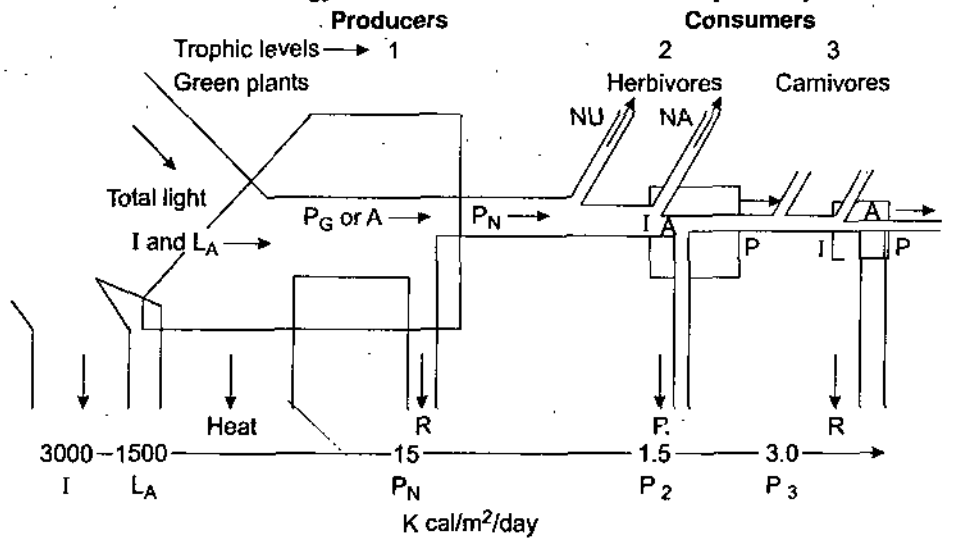


Fig. 12. A simplified energy flow diagram showing three trophic levels (Boxes numbered 1, 2, 3) in a linear food chain/I—total energy input; LG—light absorbedby plant cover. PG—gross primary production. A—Total assimilation. PN—net primary production. P_G—secondary (consumer) production. NU—Energy not used (stored or exported). NA—energy not assimilated by consumers (Egested). R—respiration. Bottom line in the diagram shows the order of the magnitude of energy losses expected at major transfer points, starting with a solar input of 3,000 kcal per square meter per day.

thermodynamics and energy transfer is accompanied by dispersions of energy into unavailable heat, *i.e.*, respiration as required by the second law. Figure (12) shows a very simplified energy flow model of three trophic levels. It shows that the energy flow is greatly reduced at each successive trophic level from produce to herbivoes and then to carnivores. So, at each transfer of energy from one level to another, a major part of energy is lost in the form of heat or other form. Thus, there is a successive reduction in energy flow whether we consider it in terms of total flow, *i.e.*, total energy input and total assimilation or secondary production and respiration components. So, of the 3,000 kcal of total light incident on the green plants, nearly 50 percent (1500 k cal) is absorbed of which only 1 percent (15 k cal) is changed at first trophic level. Thus, net primary production is simply 15 k cal. Secondary productivity (P_2 and P_3 in the figure) tends to be nearly 10 percent at successive trophic levels, *i.e.*, herbivores and the carnivores, although efficiency may be higher, as 20 percent, at the carnivore level as shown (or $P_3 = 0 \cdot 3$ k cal) in the figure.

From figures (11) and (12), it is clear that there is a successive reduction in energy flow at successive trophic levels. Therefore, shorter the food chain, greater would be the available food energy, because an increase in the length of food chain results in more loss of energy.

[II] Y-Shaped Energy Flow Models

H.T. Odum (1956) gave the energy flow models as shown in figure (13). In them, is shown a common boundary and in addition to light and heat flows, the import, export and storage of organic matter are also included. Decomposers are put in a separate box as a means of partially separating the *grazing* and *detritus food chains*. Decomposers are in fact a mixed group in terms of energy levels.

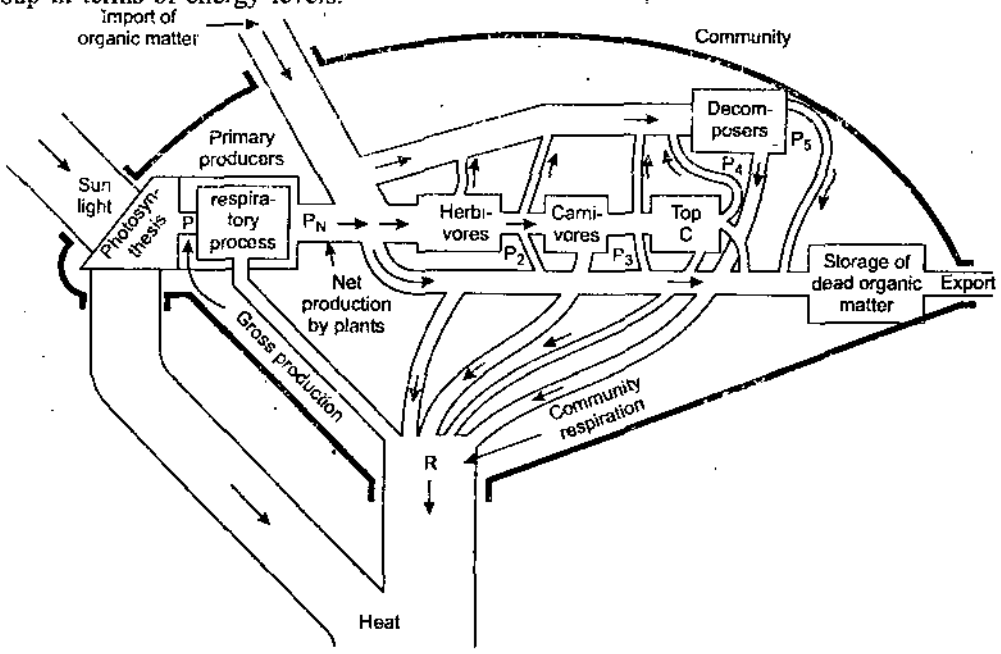


Fig. 13. The relationship between flow of energy through the grazing food chain and detritus pathway.

Figure (14) represents two *Y*-shaped or 2-channel energy flow models. In each *Y*-shaped model, one arm indicates the herbivore food chain and the other, the decomposer (detritus) food chain. Fundamentally, the two arms differ in the way in which they can influence primary producers. In each model, the grazing and detritus food chains are sharply separated. This figure contrasts the biomass energy flow relationships in the sea and the forest. In the marine bay, the energy flow *via* the grazing food chain is shown to be larger than via the detritus food chain (forest), whereas the reverse is shown for the forest in which 90 percent or more of the net primary production is normally used in detritus food chain. So, in marine ecosystem, the grazing food chain is the major pathway of energy flow, whereas in the forest ecosystem, the detritus food chain is more important. In grazing food chain, herbivores feed on living plants and, therefore, directly affect the plant population. What they

do not eat, is available, after death, to the decomposers. Due to this, decomposers are not able to directly influence the rate of supply of their food. Such difference is not necessarily found in aquatic and terrestial ecosystems. In grassland or heavily grazed pasture, 50 percent or more of the net production may pass down the grazing path, whereas there are several ecosystems especially shallow water ones, that like mature forests, operate largely as detritus systems. As not all food eaten by grazers is actually assimilated, some is diverted to the detritus route. So, the impact of the grazer on the community depends on the rate of removal of living plant material as well as on the amount of energy in the food that is assimilated. Marine zooplankton commonly graze more phytoplankton than they can assimilate, the excess being egested to the detritus food chain. Therefore, the energy flow along various paths depends on the rate of removal of living plant material by herbivores as well as on the rate of assimulration in their bodies. Further, the *Y*-shaped model shows that under natural *conditions the two food chains, are not completely isolated from one another. For example,* dead bodies of small animals that were once part of the grazing food chain become incorporated in the detritus food chain as do the feces of the grazing food animals. Functionally, the difference between the two is of time lag between the direct consumption of living plants and final utilisation of dead organic matter.

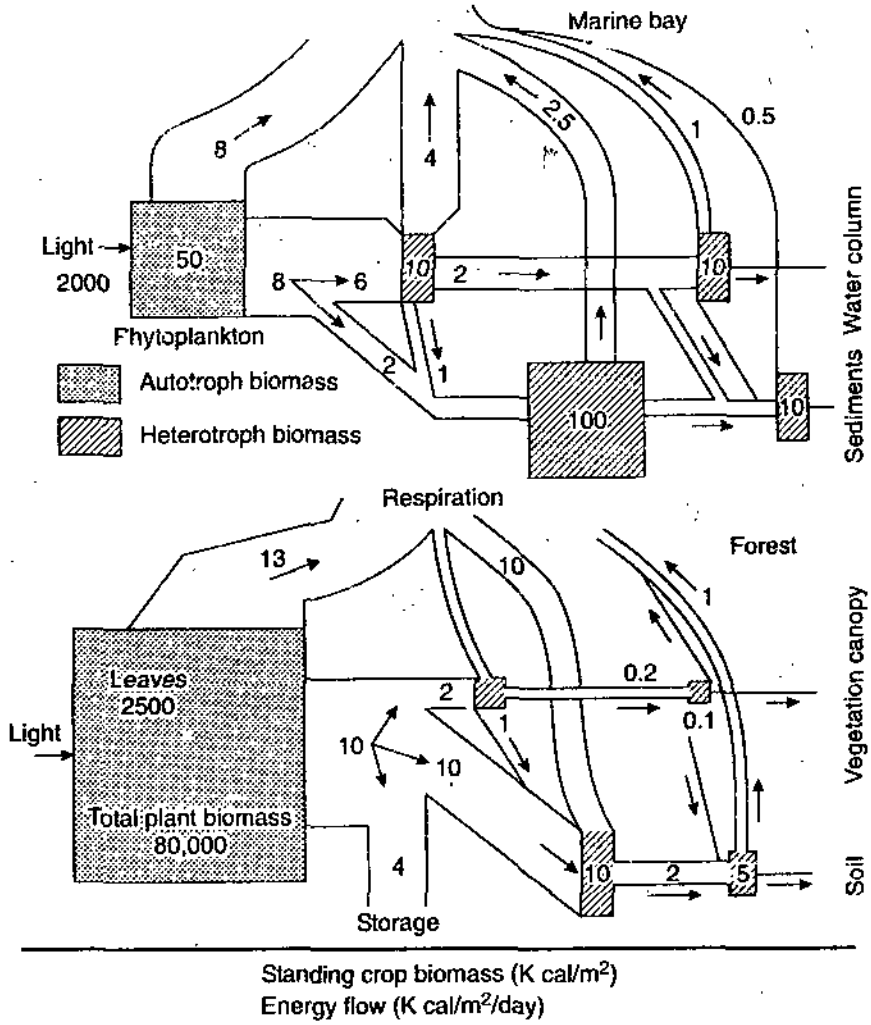


Fig. 14. A Y-shaped or 2-channel energy flow diagram that separates a grazing food chain (water column or vegetation canopy) from a detritus food chain (sediments and in soil). Estimates for standing crops (shaped boxes) and energy flow compare a hypothetical coastal marine ecosystem (upper diagram) with a hypothetical forest (lower diagram).

The important point in *Y*-shaped model is that the two food chains are not isolated from each other. This model is realistic and practical working model than the single channel model because of the following reasons :

(i) *Y*-shaped model conforms to the basic stratified structure of ecosystems.

(ii) It separates the grazing and detritus food chains in both time and space.

(iii) The microconsumers, *i.e.*, absorptive bacteria, fungi and the macro- consumers, *i.e.*, phagotrophic animals differ greatly in size-metabolism relations.

[III] Generalised Y-shaped Energy Flow Models

E.P. Odum (1983) introduced a generalised 2-channel or *Y*-shaped energy flow model [Figure (15)], which is applicable to both aquatic and terrestial ecosystems. Figure (16)

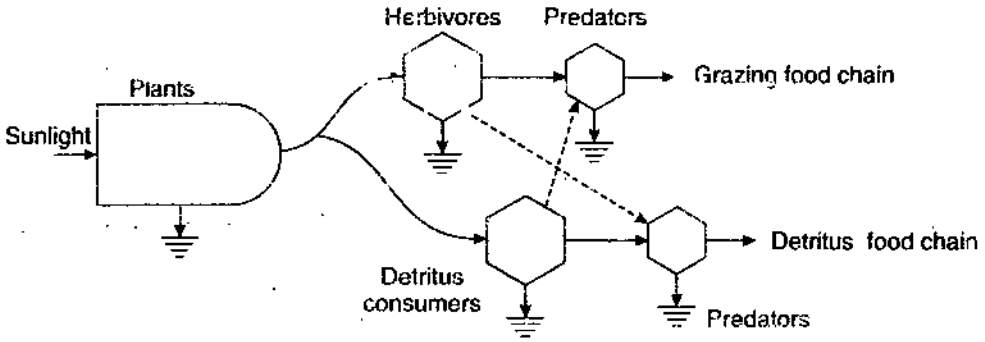


Fig. 15. The Y-shaped energy flow model showing linkage between the grazing and detritus food chains.

presents the so called universal model, one that is applicable to any living component, whether a plant, animal, individual, micro-organism, population or a trophic group. Such a model may represent food chain as already shown in single or *Y*-shaped energy flow systems or the bioenergetics of the complete ecosystem. In figure (16), the shaded box, labelled '*B*' denotes the living structure or biomass of the component. The total energy input or intake is denoted by '*I*' which is light for strict autotrophs and organic matter for strict heterotrophs. This universal energy flow model can be used in the following two ways :

(i) It can denote a species population in which case the appropriate energy inputs and links with other species would be shown as a conventional species oriented food web diagram.

(ii) The model can show a discrete energy level in which case the biomass and energy channels represent all or parts of many populations supported by the same energy sources. For example, foxes usually get part of their food by eating plants, fruit etc and part by eating herbivores like field mice, rabbits etc. A single box figure could represent the whole population of foxes, if our objective is to stress intrapopulation energetics. On the contrary, two or more boxes, as shown on the right of

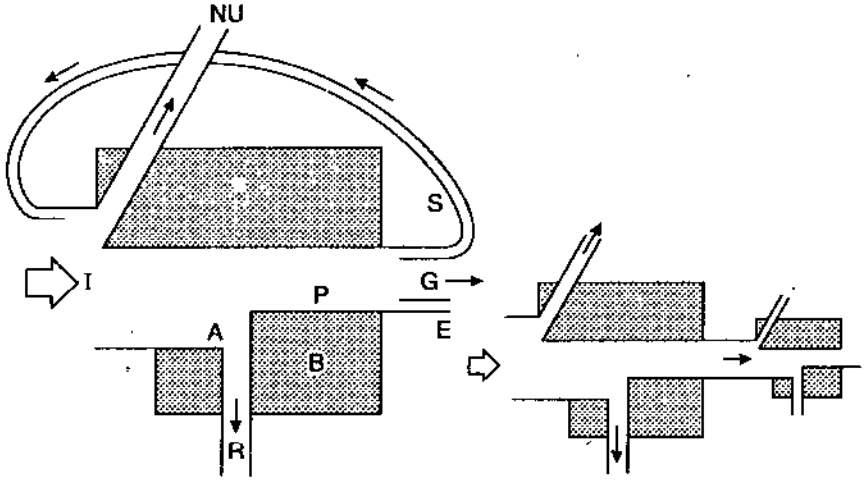


Fig. 16. Components for a "universal" model of energy flow, I = Input or ingested energy, NU = not used, A= assimilated energy, P = production, R = respiration, B = biomass, G = growth, S = stored energy, E = excreted energy.

figure (16), would be used if we wish to separate the metabolism of a population into two or more trophic levels in accordance with the proportion of plant and animal consumed.

If should be remembered that these models represent the basic pattern of energy flow in ecosystem. In practice, under natural conditions, the organisms are inter-related in such a way that several food chains become interlocked and this gives a complex food web. The complexity of food web depends on the length of the food chains. So, in nature, multi-channel energy flows operate, but in these the channels belong to either grazing food chain or detritus food chain. Interlocking pattern of such several chains in food web of an ecosystem leads to a multi-channel flow of energy. Therefore, in actual practice, under field conditions, the measurement of energetics of ecosystem might be difficult.

2.3. ECOLOGICAL SUCCESSION

[I] Community

Groups of different kinds of population in the area are together known as ***community.*** In other words, it can also be defined as a group of several species living together in a natural area. Organisms in a community inhabit a common area that has the same uniform environment.

[II] Ecological Succession

A community has a tendency to stabilise. The organisms and the environmemt interact with one another to have a balance and community becomes self sufficient and self sustainable. However, such an equilibrium has a short time. Though, community becomes theoretically stabilised, in practice it is always dynamic in nature and change gradually with the passage of time. These changes replace one community by another. The process of replacement continues and successive communities develop one after the other in the same area till the final or terminal community again becomes more or less stable for an interval of time. So, **the successive replacement of communities in an area over a period of time is known as ecological succession or biotic succession.**

(1) Characteristics of Ecological Succession :

(a) The interacting organisms change the physical environment. Moreover, the interaction between biotic and physical factors changes the environment under which a new set of organisms grow and develop.

(b) The replacement of one community is followed by an orderly series of communities gradually one after the other. This community change and set of conditions are related to each other which is known as **sere.** It is composed of a number of biotic succession (communities). The last succession or a community in a sere in known as **climax** or **climatic climax.**

(c) The changes in the local environment are more suitable for the survival of other organisms.

(2) Causes of Ecological Succession : The basic causes of ecological succession are as follows :

(a) Initial or initiating causes : Climatic as well as biotic factors mainly start a succession. Climatic factors include wind, fire, soil erosion, soil deposits etc. while the biotic factors include interaction amongst organisms. These factors either produce bare areas or eliminate the existing vegetation.

(b) Stabilising causes : Climate of an area is the main factor that allows the new community to settle down.

(c) Ecesis or continuing causes : The processes, *e.g.*, aggregation, migration, competition reaction etc allow the effect of changes to continue.

(3) Types of Ecological Succession : Based on a particular factor, habitat, space or community, the ecological succession can be classified into the following types :

(a) Primary succession : This type of succession occurs on a previously sterile area such as a newly exposed sea floor, bare rocks and dunes etc. These areas can be

inhabited by highly hardy species. **Such first group of organisms to establish in these areas where no living matter was present is known as pioneer, primary community or primary colonisers.** Lichens generally form pioneer community when the area is sterile. This community is then successively followed by mosses, annual grasses, perennial shrubs, shrubs and finally the trees. The grasslands and forest generally represent climax communities.

(b) Secondary succession : This type of succession occurs in an area where a community was already existing, but has been destroyed mostly due to fires, flood, landslides, earthquake etc. Only a few organisms and an appreciable amount of organic matter remain in the area. The remaining species and those growing on organic matter form a new community, the pioneer community.

A primary succession may take a very long time, say anywhere upto 1000 years to reach the climax community. However, secondary succession takes a much shorter time to reach the climax community. For example, a destroyed grassland may take 50–100 years, while destroyed forest takes more than 250 years to form a climax community.

(4) General Processses of Ecological Succession : Every primary succession, irrespective of the bare area from which it initiates, exhibits the following five steps which follow in succession stages.

(a) Nudation : *This step involves the development of bare area which may be due to* soil erosion, deposition etc.

(b) Invasion : This step involves the successful establishment of a species in a bare area. The species reaches this area from some other region.

(c) Competition and co-action : The species having occupied new area develops intra and inter-specific competition for food and space. The competition between already existing species and those which have just entered the area, results in the destruction of one of them which is unsuitable.

(d) Reaction : The species or the community that has established itself in a new area, affects the environment by modifying light, water, soil etc. This results in elimination of a community which then makes way for another community for which the modified environment is more suitable. The different communities or stages represented by combination of mosses herbs, shrubs and trees replacing one another during succession are known as **seral stages, seral communities** or **developmental stages.**

(e) Stabilization : This is the final stage, during the course of succession when a community attains an equilibrium with the climate of an area and becomes *comparatively stable.*

(5) Ecological Succession Based on Habitat : The following types of succession are known which are based on the type of habitat :

(i) ***Hydrosere or hydrarch*** : This type of succession occurs in water bodies like ponds, lakes, streams etc.

(ii) ***Xerosere or Xerarch*** : This type of succession occurs in terrestial areas with low moisture, *e.g.*, rock, sand etc.

(iii) ***Lithosere*** : This type of succession starts on a bare rock.

(iv) ***Halosere*** : This type of succession starts on saline water or soil.

(v) ***Psammosere*** : This type of succession starts on a sandy area.

[III] Hydrosere or Hydrarch

Ecological succession also occurs in water bodies like lakes, ponds etc. Water bodies are prone to silting due to soil erosion from surrounding areas. Blockage of rivers by landslides and construction of dams lead to formation of new lakes, ponds on land where hydrarch succession sets in due to invasion of aquatic species. The following description generalises the majo. stages of this type of succession figure (17).

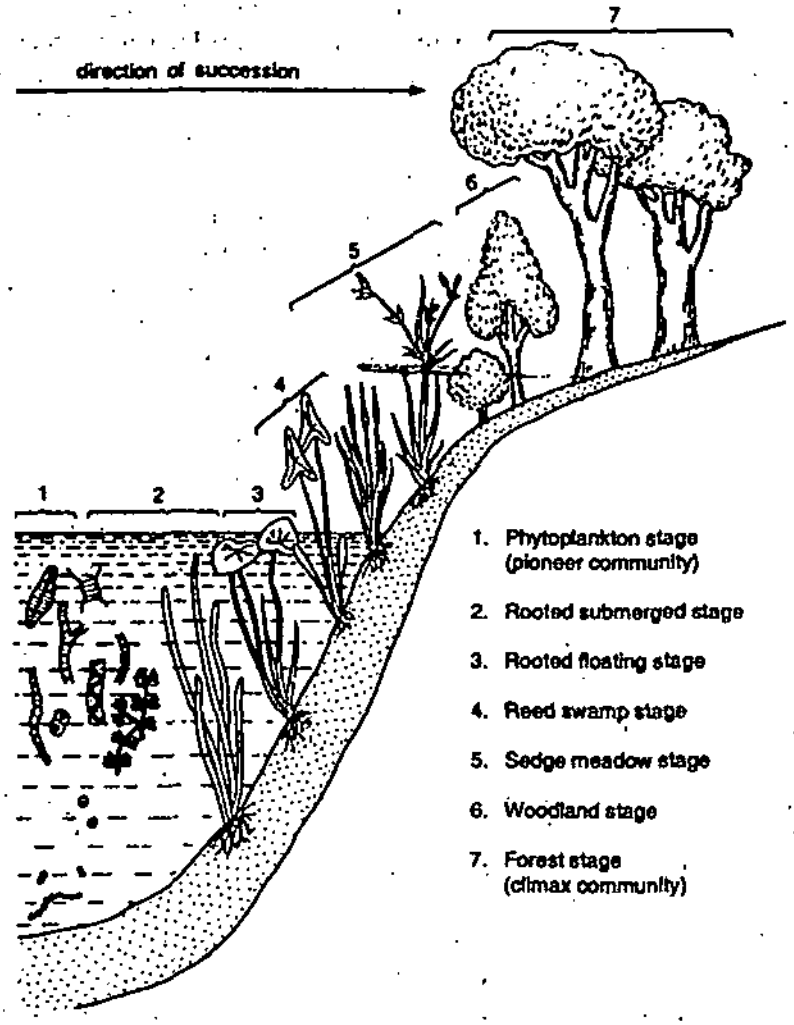


Fig. 17. Hydrosere : Different seral stages.

(i) ***Phytoplankton or zooplankton stage*** **:** This is the first community or pioneer community to appear in a pond or a pool of water. It consists of blue-green algae, green algae, diatoms, bacteria etc. The organisms of this community multiply, but as they increase in number, they die, adding organic matter and nutrients to the habitat. This habitat now becomes unsuitable for phytoplanktons to continue.

(ii) ***Rooted submerged stage*** **:** The pond now becomes shallow. This habitat is now suitable for submerged aquatic plants with their roots anchored in the mud. The dead remains of these organisms settle at the pond bottom.

(iii) ***Rooted floating stage*** **:** Due to the death of rooted submerged plants, more organic matter is added to the pond which now becomes much shallower, being almost 2–5 feet deep. Some free floating plants also begin to appear on water surface.

The amount of organic matter now added is very high and so the habitat becomes unsuitable for rooted floating and free floating plants. The pond is now filled with large amount of organic matter and such a shallow pond is not suitable for the growth of existing community.

(iv) ***Reed swamp stage*** **:** With the continued siltation, the pond bottom is gradually raised and water layer becomes shallow and rich in nutrients. As a result, rooted emergent plants with aerial leaves, such as reeds are able to colonise the pond.

(v) ***Sedge meadow stage*** **:** In the beginning, the area exhibits marshy conditions. This is suitable for plants which have a high rate of transpiration, causing quick water loss and so the soil continues to become mesic. As succession continues, marshy meadows becomes too dry for swampy plants and these are subsequently replaced by herbs and shrubs.

(vi) *Woodland stage* : With increased settling of silt and deposition of dead organic matter derived from floating and rooted species, the pond becomes shallower until it gets transformed into terrestial plants, grasses, shrubs and trees.

(vii) *Forest stage* : The woodland stage is short lived and it is quickly replaced by trees. Ultimately, the trees form a thick forest. The nature of trees in a forest is determined by whether the succession occurs in a tropical or temperate area.

[IV] Xerosere-Lithosere

Lithosere is a xerosere (xerarch) that occurs on a bare rock surface. In other words, *the succession that takes place in dry conditions is* called *xerosere.* This habitat lacks water and organic matter. The substratum consists of minerals in disintegrated unweathered state. The pioneer community is formed by crustose lichens, whereas the forest forms the climax community. The different stages of a lithosere [Fig. (18)] are as follows :

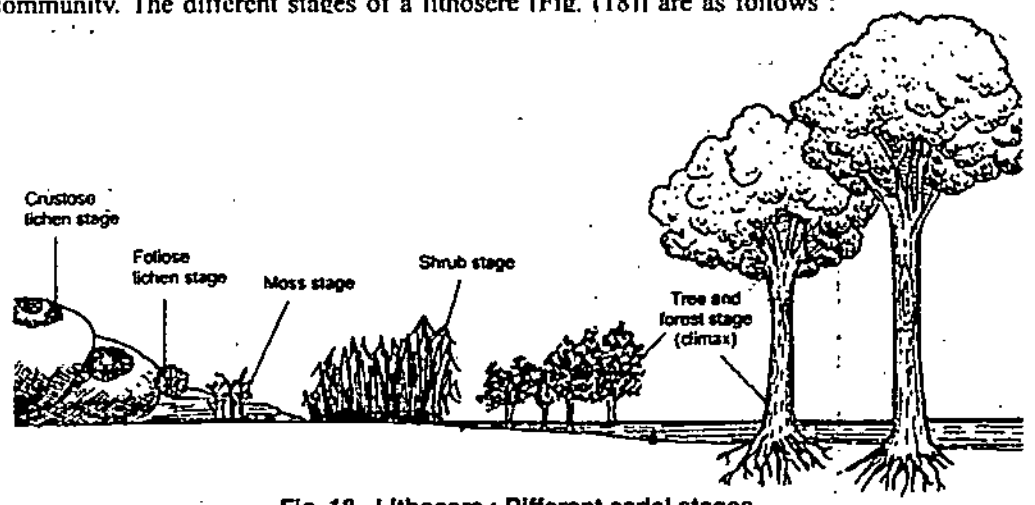


Fig. 18. Lithosere : Different serial stages.

(i) *Crustose lichen stage* : Due to great exposure to sun and extreme deficiency of water, the first pioneers on the bare rock area are a few simple organisms. The most successful of such organisms are crustose lichens. These are able to withstand extreme desiccation due to extreme dryness. During rainy season, they absorb large quantities of water and flourish rapidly.

(ii) *Lichen moss stage* : Lichens release some acid which slowly corrode the rocks producing a few mineral particles. The lichens form a crust over the bare rocks and begin to form soil from their organic remains and by stimulating chemical breakdown of the rocks. Lichens are normally followed by mosses, which speed up the soil accumulation by trapping wind blown particles. Mosses grow in bunch and together with lichens make a mat over the substratum. Lichens and mosses which get established on barren rock, are the pioneer species forming the pioneer community.

(iii) *Herb stage* : The accumulation of soil particles in the lichen-moss carpet provides suitable substratum for the germination of seeds of herbaceous plants which are dispersed in it The seeds of higher plants germinate and grow successfully in pockets of newly formed soil on the rock.

(iv) *Shrub stage* : Gradually, more soil with the addition of humus is accumulated and herbaceous species make way for the invasion of shrubs.

(v) *Forest stage* : The weathering of rocks increase the amount of soil particles and the death and decay of shrubs adds large amount of humus to the soil. This substratum favours the growth of trees. In the beginning, trees show stunted growth and are sparsely placed. Passing through the seral stages in course of time, climax forest community gets established.

Depending on the climatic conditions and extent of soil formation, the climax community is generally dominated by trees. If the climax conditions do not change and no catastrophic event changes the area, the community maintains itself indefinitely. The changes in biotic community from the pioneer to the climax stage may take hundreds of years.

2.4. DIFFERENT ECOSYSTEMS

[I] Forest Ecosystem

Forests occupy nearly 40 percent of the land. In India, the forests occupy nearly 10 percent of the total land area. The different components of a forest ecosystem are as follows :

(1) Abiotic components : These are the organic as well as inorganic substances present in the soil and atmosphere. Besides the presence of minerals in forests, we find the dead organic matter—the litter accumulation, mainly in temperate climate. Moreover, the light conditions are different because of the complex stratification in the plant communities.

(2) Biotic components : The lving organisms present in the food chain are present in the order given below :

(a) Producers : Producers are chiefly trees that exhibit much species diversity and greater degree of stratification especially in tropical moist deciduous forests. The trees are of different types depending on the kind of the forest formation developing in that climate. Besides trees, there also exist ground vegetation and shrubs. In these forests, dominant members of the flora, the producers are trees, *e.g.*, *Tectona grandis, Shorea rubusta* and *Lagerstroemia parviflora* etc. In temperate coniferous forests, shrubs and ground flora are insignificant. In temperate deciduous forests, the dominant trees are species of *Acer, Betula, Thuja, Picea* etc. In temperate coniferous forests, the producer trees are species of *Abies, Pinus, Cedrus, Juniperus, Rhododendron* etc.

(b) Consumers : These are classified as follows :

(i) Primary consumers : These are herbivores that include the animals feeding on tree leaves, *e.g.*, ants, flies, leafhoppers, bugs, spiders etc, larger animals grazing on shoots and/or fruits of the producers, *e.g.*, elephants, deer, nilgai, squirrels, flying foxes, mongooses etc.

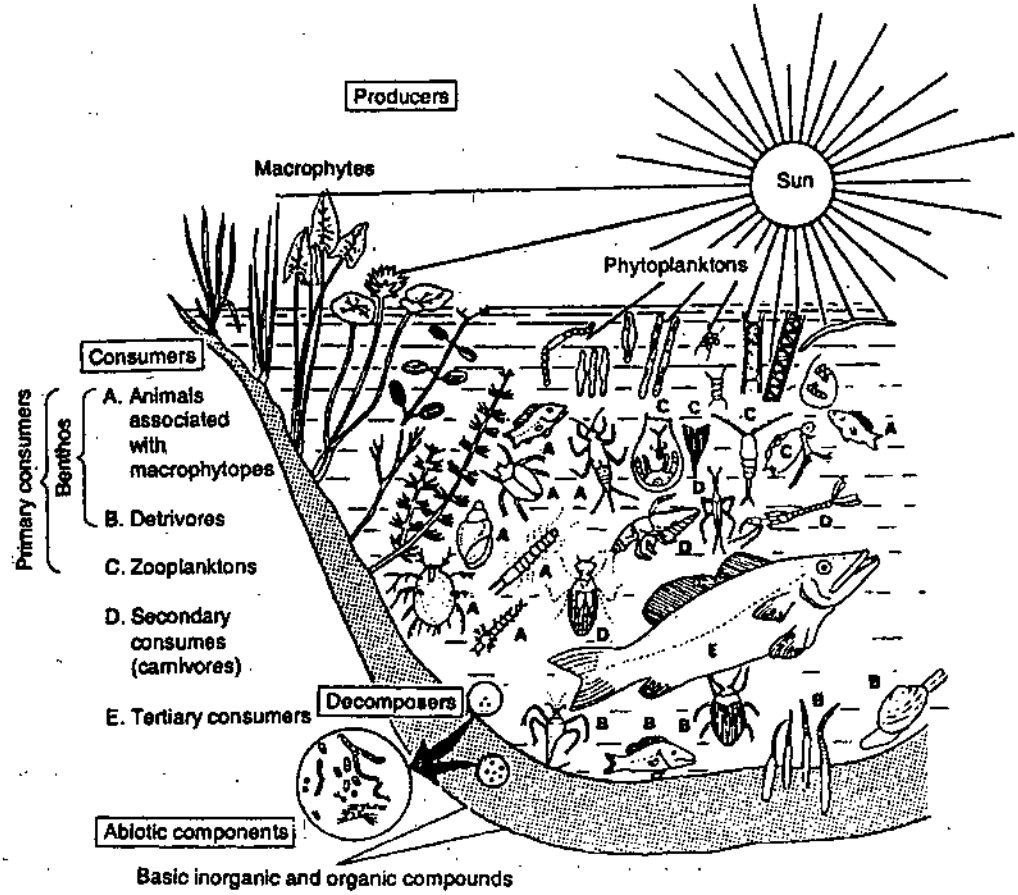


Fig. 19. Forest ecosystem.

(ii) Secondary consumers : These are carnivores like snakes, birds etc that eat and feed on herbivores.

(iii) Tertiary consumers : These are the top carnivores like tiger, lion etc that eat carnivores of secondary consumers level.

(c) Decomposers : These include wide variety of micro-organisms like fungi, bacteria and actinomycetes etc. Rate of decomposition in tropical and subtropical forests is more rapid than that in the temperate ones.

[II] Grassland Ecosystem

Grassland ecosystem is a type of terrestial ecosystem. Grassland occupy a comparatively lesser area, nearly 19 percent of the earth's surface. Grassland ecosystems have treeless herbaceous plant cover, dominated by a wide variety of grass species. Associated with grasses are several herbaceous dicotyledonous species, especially legumes which play an important role in nitrogen economy. The different components of a grassland ecosystem are mentioned below.

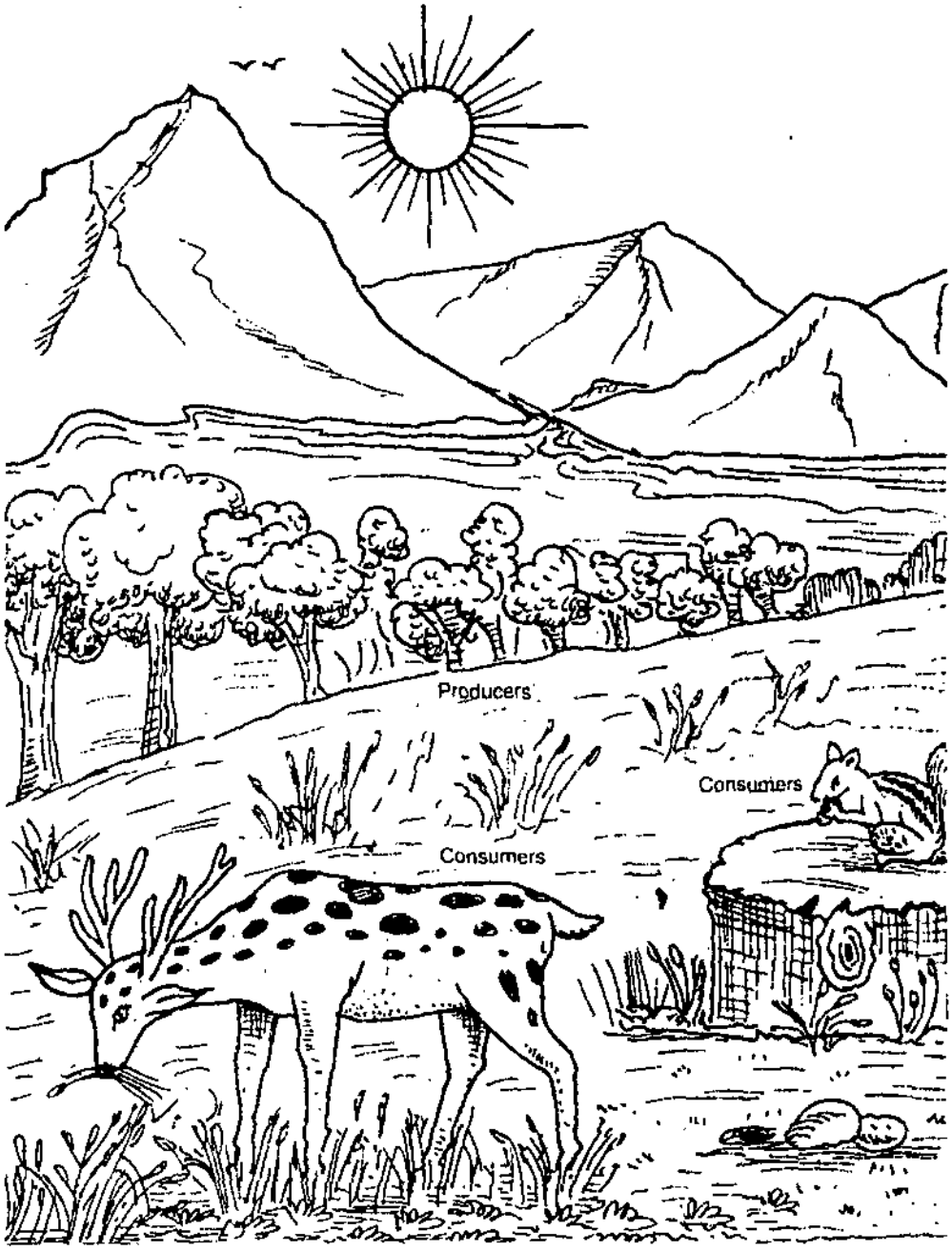


Fig. 20. A grassland ecosystem.

(1) Abiotic components : Abiotic components are the nutrients present in soil and the aerial environment. Therefore, the elements, *e.g.*, C, H, O, N, P, S etc are supplied by carbon dioxide, water, nitrates, phosphates and sulphates etc, which are present in air and soil of the area. Besides the above elements, some trace elements are also present in the soil.

(2) Biotic components : Biotic comprents can be classified as follows :

(a) Producers : Producers are chiefly grasses, few forbs and shrubs etc.

(b) Consumers : Consumers occur in the following order :

(i) Primary consumers : The herbivores feeding on grasses are chiefly such grazing animals like cows, buffaloes, sheep, deers, rabbit, mouse etc. Besides these animals, there are also present some insects like *Dysdercus, Leptocorisa, Cicincella* etc, some termites and millipeds that feed on the leaves of the grasses.

(ii) Secondary consumers : Secondary consumers are carnivores feeding on herbivores. These include animals like birds, frogs, snakes, lizards, jackals, foxes etc. Sometimes, the hawks feed on the secondary consumers, thus occupying tertiary consumer level in the food chain.

(c) Decomposers : Decomposers are microbes active in the decay of dead organic matter of diffferent forms of higher life, *e.g.*, fungi, as species of *Mucor, Aspergillus, Penicillium, Rhizopus* etc., some bacteria and actinomycetes. They bring about the minerals back to the soil, thus making them available to the producers.

[III] Desert Ecosystem

Deserts occupy nearly 17 percent of land occurring in areas with an annual rainfall of less than 25 centimeters. The species composition of such ecosystem is much more varied and typical due to the extremes of both water and temperature factors. The different biotic components are as follows :

(a) Producers : Producers are shrubs, especially bushes, some grasses and a few trees. The shrubs have widespread, branched root system with their stems and branches quite modified. Sometimes, a few succulents like cacti are also present. Some lower plants, *e.g.*, lichens, xerophytic mosses may also be present.

(b) Consumers : Consumers are the most common animals like reptiles and insects which can live under xeric conditions. Besides these, nocturnal rodents and birds are also found. The camels, known as '*ship of desert*' feed on tender shoots of the plants.

(c) Decomposers : Decomposers in forests are very few, because the amount of dead organic matter is correspondingly less due to poor vegetation. Some fungi and bacteria, most of which are thermophilic act as decomposers.

Physical Features : Pleistocene alluvial plains varyingly covered by younger wind worked sands constitute by far the most extensive feature of the arid region. These plains have an elevation of 350–450 m above the sea level. Most spectacular among the land forms are the ***dunes***, which in arid Rajasthan cover, in varying degrees of frequency, 58 percent of the area. Dunes occur in two major chains one lying in the western parts of Barmer, Jaisalmer and Bikaner districts, made up of often 20–100 m high and many kilometers long dunes and the other covering eastern parts of Bikaner and Churu districts. The dunes are highly sandy and contain only 1·8 to 4·5 percent clay and 0·40 – 0·3 percent silt.

The dominant soils of the arid zone are highly texured and devoid of any significant structural developments. These are prone to severe wind erosion. They have very low water retention capacity. The sand also allows easy root penetration. Sandy soils are well provided with various elements, including tracer elements; humus/nitrogen are very low.

The vegetation is of thorn forest type. But natural vegetal cover is greatly changed due to biotic influence. Much arid zone area has come under cultivation. Natural vegetation contributes to productivity of trees like *Khejri* (*Prospis cineraria*). Lions, tigers, cheetah, leapords are also found in desert region.

Deserts have been variously classified as ***true deserts***, having less than 12 cm annual rainfall or ***extreme deserts*** showing less than 7 cm annual rainfall. On the basis of temperature, deserts are distinguished into ***hot deserts*** and ***cold deserts***. Most of the deserts

are distributed around the Tropic of Cancer and Tropic of Capricorn between 15 ⊃ and 30 ⊃ latitudes in both northern and southern hemispheres. Warm or hot days and cool nights are the characteristics of most deserts.

[IV] Pond Ecosystem

A pond as a whole serves a good example of a fresh water ecosystem. A pond shows a self sufficient, self regulating system. Not only is the pond a place where plants and animals, *i.e.*, living organisms live, but plants and animals make the pond what it is (physico-chemical environment). The different components of a freshwater pond ecosystem are discussed below.

(1) Abiotic components : The pond water has dissolved calcium, nitrogen phosphate etc. Organic substances, *e.g.*, amino acids and humic acids are also present in the pond. Besides these, pond water also contains dissolved oxygen and carbon dioxide. The climatic factors like heat, light, temperature etc affect the abiotic components of a pond.

(2) Biotic components : Biotic components include various organisms as follows :

(a) Producers : Producers are autotrophic, green plants and some photosynthetic bacteria. The producers fix radiant energy and with the help of minerals derived from water and mud, they manufacture complex organic substances, *e.g.*, carbohydrates, proteins, lipids etc. Producers are of the following types :

(i) **Macrophytes :** These are mainly rooted larger plants which include partly or completely submerged, floating and emergent hydrophytes. The common plants are the species of *Salvinia, Wolffia, Pistia, Hydrilla, Vallisneria, Trapa, Nymphaea, Jussiaea, Typha, Scirpus, Ranunculus* etc.

(ii) **Phytoplanktons :** These are minute, floating or suspended lower plants. Majority of them are such filamentous algae as *Ulothrix, Spirogyra, Cladophera* etc. Besides them there are also present some chlorococcales, *Cosmorium, Pandorina, Volvox, Microcystis, Spriulina* etc.

(b) Consumers : They are heterotrophs which depend on plants. Most of the consumers are herbivores, a few as insects and some large fish are carnivores feeding on herbivores. Some fish also feed on other carnivores as well. The consumers are distinguished as follows :

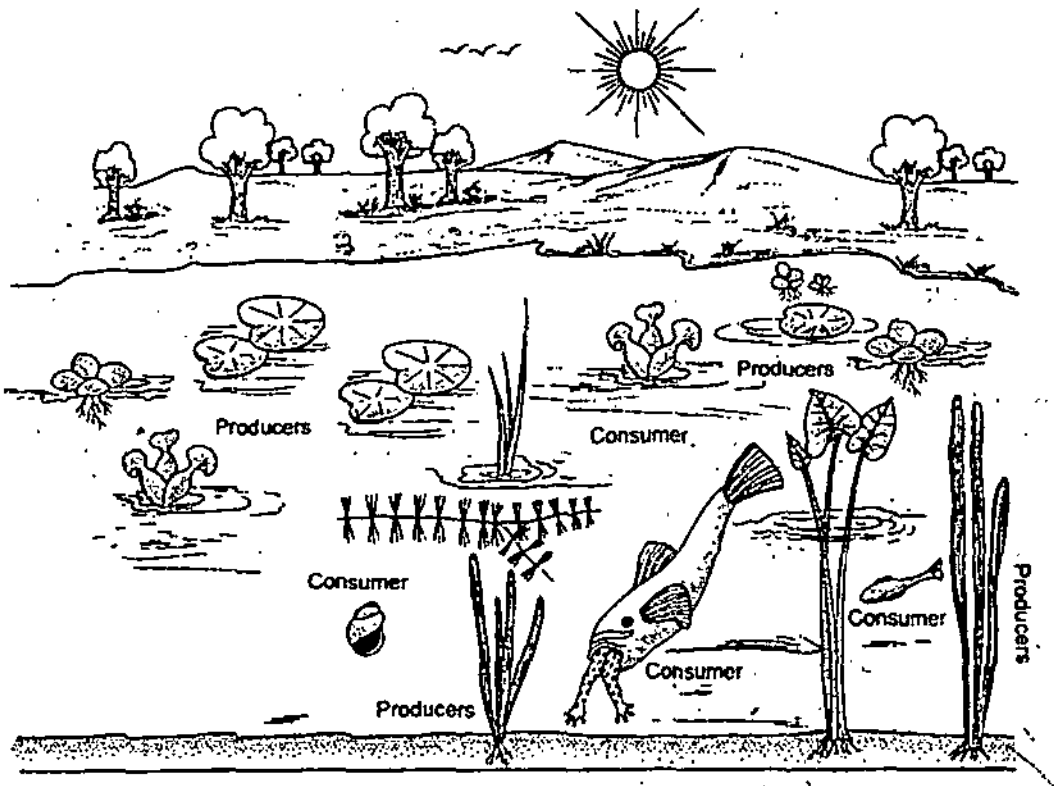


Fig. 21. The major components of a freshwater pond ecosystem.

(i) ***Primary consumers*** : These organisns feed on algae present in the pond. Examples are *Euglena, Coleps, Brachionus* etc.

(ii) ***Secondary consumers*** : These include fishes, mites and beetles etc.

(iii) ***Tertiary consumers*** : There are some large fish as game fish that feed on the smaller fish and thus become the tertiary (top) consumers as shown in figure (21).

(c) Decomposers : They are also known as **microconsumers,** since they absorb only a fraction of the decomposed organic matter. They bring about the decomposition of complex dead organic matter of both producers (plants) as well as the macroconsumers (animals) to simple forms. So, they play an important role in the return of the mineral elements again to the medium of the pond. These include a number of heterotrophic microbes that are osmotrophs. They are mainly bacteria, fungi and actinomycetes, which are generally found at the bottom of the pond.

[V] Ocean (Marine) Ecosystem

The oceans of the world, viz., Indian, Arctic, Atlantic, Pacific and Antarctic cover nearly 70 percent of the earth's surface. Each ocean represents a very large and stable ecosystem. Marine environments are more stable as compared to fresh water, in their chemical composition due to being saline and moreover other factors as dissolved oxygen content, light and temperature are also different. The biotic components of an ocean are of the following orders :

(a) Producers : Producers are autotrophs and also known as primary producers, as they are responsible for trapping the radiant energy of the sun with the help of their pigments. Producers are chiefly the phytoplanktons, such as diatoms, dinoflagellates and some microscopic algae. Besides them, a number of macroscopic seaweeds such as brown and red algae also contribute significantly to primary production. These organisms exhibit a clear zonation at different depths of water in the sea.

(b) Consumers : Consumers are all heterotrophic macroconsumers, because they depend on the primary producers for their nutrition. These are classified as :

(i) ***Primary consumers*** : The ***herbivores*** that feed directly on producers are mainly molluscs, fish, crustaceans etc.

(ii) ***Secondary consumers*** : These are ***carnivores*** fish, *e.g., Herring, Mackerel, Shad* etc. which feed on the herbivores.

(iii) ***Tertiary consumers*** : In the food chain, there are still other carnivorous fishes like *Haddock, Cod, Halibut* etc which feed on other carnivores of the secondary consumers level. So, these are the top carnivores in the food chain.

(c) Decomposers : The microbes active in the decay of dead organic matter of producers and macroconsumers are mainly some fungi and bacteria.

[VI] Estuarine Ecology

An ***estuary*** *is a semi-closed coastal body of water which has a free connection with the open sea,* thus strongly affected by tidal action and within which water is mixed with fresh water from land drainage, *e.g.*, river mouths, tidal marshes, coastal bays, water bodies behind barrier beaches. So, estuaries may be regarded as transitional zones or ecotones between the freshwater and marine habitats.

Estuaries can be classified on the basis of their geomorphology, water circulation and stratification and systems energetics.

(a) On the basis of geomorphology, estuaries are :

(i) drowned river valleys

(ii) food-type estuaries

(iii) bar built estuaries

(iv) river delta estuaries

(v) estuaries formed by tectonic processes.

(b) On the basis of water circulation and stratification, estuaries are classified as :
   (i) highly stratified or salt-wedge estuaries
   (ii) completely mixed or vertically homogeneous estuaries
   (iii) partially mixed or moderately stratified estuaries
   (iv) hypersaline estuaries

(c) On the basis of ecosystem energetics, estuaries are classified as :
   (i) physically stressed systems of wide latitudinal range
   (ii) natural temperate coastal ecosystems
   (iii) natural tropical coastal ecosystems of high diversity
   (iv) natural arctic ecosystems with ice stress
   (v) emerging new systems associated with humans.

The ***communities*** of estuaries consist of a mixture of endemic species and those which come in from sea. An estuary consists of a number of basic subsystems linked together by the ebb and flow of water that is driven by the hydrological cycle and the tidal cycle. The main subsystems are :

(a) Shallow water production zones : In this zone, the rate of primary production is greater than the rate of community respirations. The producers are reefs, banks, seaweed, algae mats and salt marshes. Estuaries have all the types of producers, the macrophytes (seaweeds, sea grass and marsh grasses), benthic microphytes and phytoplanktons.

(b) Sedimentary subsystems : These are available in the deeper channels, sounds and lagoons in which respiration exceeds production and in which the particulate and dissolved organic matter from the production zone is used. Here nutrients are regenerated, recycled, stored and vitamins and growth regulators are prepared. The consumers are more or less similar to those present in marine environment though well developed in estuaries.

(c) Plankton and nekton : They move freely between the two above mentioned fixed subsystems. They keep on producing, converting and transporting nutrients and energy while responding to tidal, diurnal and seasonal periodicities.

• 2.5. BIODIVERSITY

[I] Definition and Introduction of Biodiversity

We observe a wide variety of animal life, from a small insect to a large mammal *e.g.*, an elephant living in a forest. In a forest, we may see a large variety of plant life, ranging from a tiny grass to a huge tree. Apart from animals and plants, there are a large number of micro-organisms in the soil that we cannot see by naked eyes. The occurrence of different kinds of organisms reflects the biological diversity or simply biodiversity of the forest patch. The term **biodiversity means the totality of genes, species and ecosystems of a region.** We know that all the species cannot occur at one place. The environmental conditions of the site and the range of tolerance of the species decide whether a particular species can occur on a site or not. If we study the patch of forest at two different places and compare its biodiversity then we will find that both plant life as well as animal life are different. So, *biodiversity differs from place to place.*

So, biodiversity is an ecological notion that refers to the richness of biological types at a range of hierarchical levels including.

(i) genetic diversity within species

(ii) the richness of species within communities, and

(iii) the richness of communities on landscapes.

Biologically rich and rare habitats are being destroyed, fragmented and degraded due to increasing human population, resource consumption and pollution. The loss of biodiversity has now become one of the world's most pressing issue. The main reason for this concern is the realisation that biological diversity is being lost even before its size is known. Loss of biodiversity would check the evolutionary capability of biota to cope up with environmental changes.

• 2.6. INDIA AS A MEGA DIVERSITY NATION

Systematic work on identification and naming of species has been in progress for the last 250 yesrs. To date about 1·7 million organisms have been identified and designated with a scientific name. About 6 percent of identified species live in boreal or polar latitudes, 59 percent in the temperate zones and the remaining 35 percent in the tropics. The knowledge of the global richness of species is very incomplete, particularly in the tropics. If a conservative estimate is made of unidentified tropic species, the fraction of global species that live in tropics would increase to at least 86 percent.

The number of species of plants and bacteria desribed from India are :

Angiosperms (17500), Gymnosperms (64), Pteridophytes (1100), Lichens (2000), Bryophytes (2850), Algae (6500), Fungi (14500), Bacteria (850).

Similarly, the number of species of animals deseribed from India are :

Mammalia (390), Reptilia (457), Aves (1230), Amphibia (209), Pisces (2546), Mollusca (5070), Protozoa (2577), Protochordata (119), Arthropoda (8329), Other invertebrates (8329).

Many wild animals have disappeared due to natural and human activities. About 600 species of birds and animals have become extinct due to geographical and climatic changes and also due to overhunting by man for recreation, food, fur and monetary gains.

• 2.7. LEVELS OF BIODIVERSITY

There is a large variety of organisms, complex ecological relationships among organisms, genetic diversity within species and a great type of ecological systems. Biological deversity has three hierarchical levels which are interrelated that support life on earth.

(i) Genetic diversity

(ii) Species diversity

(iIi) Community and ecosystem diversity.

[I] Genetic Diversity

Each species varying from bacteria to higher plants and animals, stores an enormous amount of genetic information. For example, the number of genes is about 450–700 in *Mycoplasma*, 4000 in *Escherichia coli*, 32000–50000 in *Oryza sativa*, 13000 in *Drosophila melanogaster* and 35000–45000 in *Homo sapiens.*

Genetic diversity means the change of genes within species; the differences could be in alleles (different variants of same genes), in entire genes (the traits which determine particular characteristics) or in chromosomal structures. The genetic diversity helps a population to adapt to its environment and to respond to natural selection. In case a species possesses more genetic diversity, it can adapt better to the changed environmental conditions. Lower diversity in a species leads to uniformity as seen with large monocultures of genetically similar crop plants. This is advantageous when increased crop production is to be considered, but it can pose a problem when an insect or a fungal disease attacks the field and poses a threat to the whole crop.

Speciation (evolution of new species) is based on the amount of genetic variation. It has a main role in the maintenance of diversity at species and community levels. The total genetic diversity of a community will be greater if there are several species as compared to a situation where there exists only a few species. Genetic diversity within a species generally increases wth environmental variability.

[II] Species Diversity

Species are distinct units of diversity, and each unit plays a specific role in an ecosystem. So, loss of ecosystem has consequences for the ecosystem as a whole. *Species diversity is related to the variety of species within a region.* The simplest measure of species diversity is species richness, *i.e.*, the number of species per unit area. The number of species

increases as the area of the site increases. In general, ***greater the species richness, greater is the species diversity.*** However, number of individuals among the species may also change, which results in the differences in evenness or equitability and consequently in diversity.

For example, suppose we have three sample areas designated by A, B and C. In sample area A, there are three species of birds. Two species are represented by one individual each, while third species has four individuals [See figure (22)]. In sample area B, that has the same three species, each species is represented by two individuals. This sample area exhibits greater evenness and there are equal chances for a species being represented in a sample. So, sample area B is considered more diverse than A. In sample area, C, the species are represented by an insect, a mammal and a bird. This sample area is more diverse as it consists of taxonomically unrelated species. In this case, we find equal number of species but varying number of individuals per species. In nature, both kind and number of species as well as the number of individuals per species change, which leads to greater diversity.

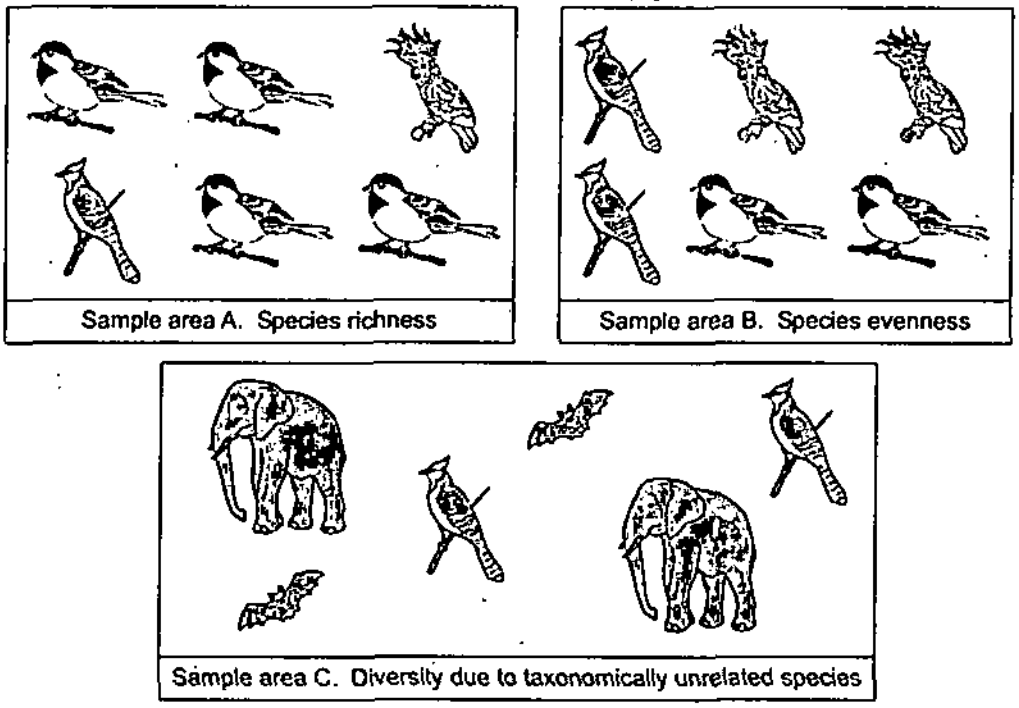


Fig. 22. The different sample areas.

[III] Community and Ecosystem Diversity

The community and ecosystem diversity can further be classified into three types :

(a) ***Alpha diversity (or within community diversity)*** : This refers to the diversity of organisms sharing the same community or habitat [See figure (23)]. A combination of species richness and evenness or equitability is employed to show diversity within a community or habitat species frequently change with the change of community or habitat.

(b) ***Beta diversity (or between community diversity)*** : The rate of replacement of species along a gradient of communities or habitats is known as beta diversity. In figure (23), there are differences in species composition of communities along environmental gradients, *e.g.*, moisture gradient, altitudinal gradient etc. It has been seen that ***higher the heterogeneity in the habitats in a region or greater the dissimilarity between communities, higher is the beta diversity.***

(c) ***Gamma diversity*** : The diversity of the habitats over the total landscape or geographical region is known as gamma diversity.

Ecosystem diversity mentions the number of niches, trophic levels and different ecological processes that sustain energy flow, ford webs and the recycling of nutrients. It mainly describes the different biotic interactions and the role and function of keystone species. From a study in temperate grasslands, we can show that diverse communities are functionally more productive and stable even in prolonged dry conditions, *i.e.*, under environmental stresses.

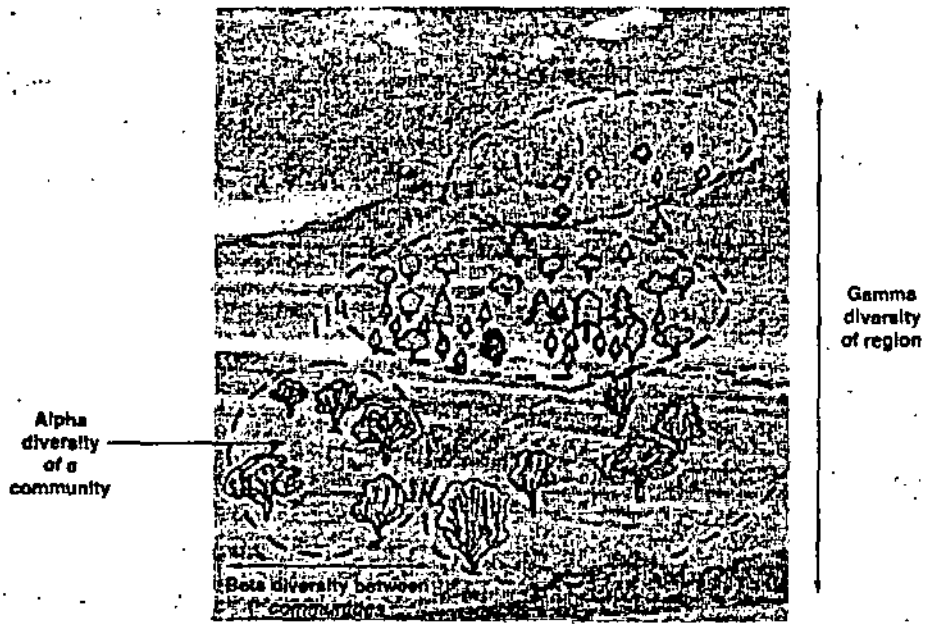


Fig. 23. Three perspectives of diversity : alpha, beta and gamma diversity.

We know that the number of ecosystems or habitats can change within a geographical area. In major ecosystems, *e.g.*, oceans, lakes and wetlands, deserts, savannas, rain forests, the species live and evolve. The biodiversity can be measured in terms of the number of habitats or ecosystems present in a region.

[IV] Biogeographical Classification of India

In India, we have a rich diversity of the biogeographically distinct regions due to different and changing physical conditions and species groupings. The different biogeographical regions of India are represented in figure (24).

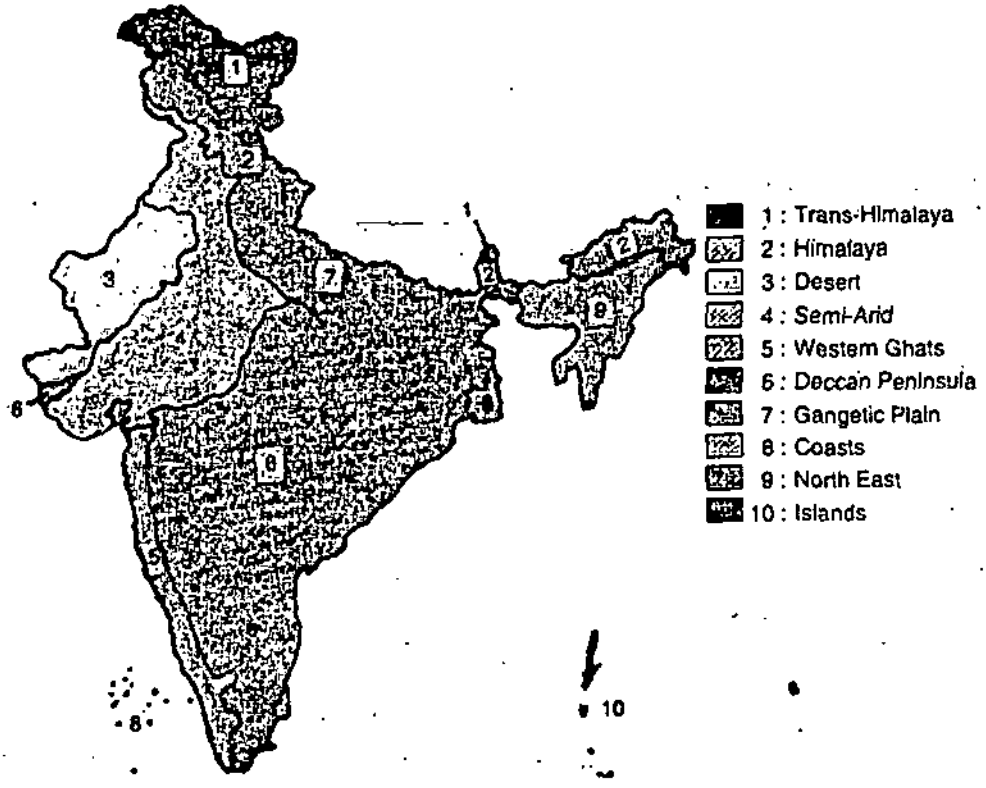


Fig. 24. Biogeographical regions of India.

Among the biogeographical regions, Deccan peninsula possesses the maximum extensive coverage of the Indian landmass (nearly 42 percent). The most biodiversity rich areas, Western Ghats and North-East has 4 and 5·2 percent of the geographical area. Each such zone has several habitats, biotic communities and ecosystems. A large number of species occurring in the areas are endemic or exclusive to India. Nearly 33 percent of the flowering *plants recorded in India are endemic to our country. For example, out of the recorded* vertebrates, 60 percent amphibians, 36 percent reptiles, 53 percent freshwater fish and 10 percent mammalian fauna are endemic. The endemics are largely concentrated in Western Ghats, North-East, North-West Himalaya and Andaman and Nicobar Islands. The number of amphibian species endemic to Western Ghats is also quite large. However, the biological diversity of many ecosystems like deep oceans, lakes and wetlands and habitats, *e.g.*, tree canopy and soil of tropical rain forests still needs exploration in India.

• 2.8. GRADIENTS OF BIODIVERSITY

Biodiversity changes with variation in altitude or latitude. As we move from lower to *higher altitudes on a mountain, we generally notice a decrease in species diversity.* A 1000 meters increase in altitude results in a temperature drop of nearly 6.5°C. This drop in temperature and greater seasonal variability at higher altitudes are major factors which reduce diversity. Similarly, as we move from high to low latitudes, *i.e.*, from the poles to the equator, the biological diversity generally increases. While in the temperate zone, the climate is severe with short growing period for plants, in tropical rain forest the conditions favour the growth throughout the year. Favourable environmental conditions favour speciation and make it possible for a larger number of species to occur and grow. For example, the mean number of vascular species per 0·1 ha sample area in the temperate zones varies from 21–48 species, whereas it is 118–236 *species in the tropical rain forests.* Figure (25) shows a correlation between latitude and diversity for a wide variety of taxonomic groups such as birds, butterflies, moths, ants etc.

The altitudinal and latitudinal gradients of species diversity are two master gradients although regional exceptions do occur. It is expected that more complex and heterogeneous the physical environment, more complex and diverse will be the flora and fauna.

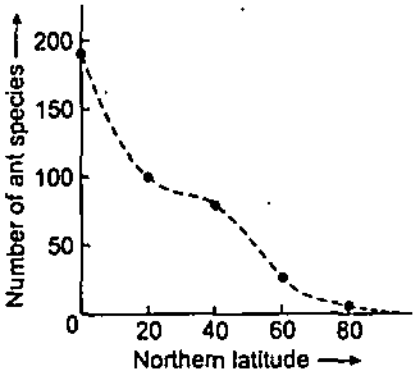


Fig. 25. Decrease in number of ant species along the latitudinal gradient (from low to high latitude).

• 2.9. VALUE OF BIODIVERSITY

Humans get several direct and indirect benefits from the living world. Biodiversity is the source of food, pharmaceutical drugs, medicines, rubber, fires and timber. The biological resourcess contain potentially useful resources also. The diversity of organisms provides many ecological services free of charge that are responsible for maintaining ecosystem health. The uses of biodiversity is explained as follows :

[I] Source of Food and Improved Varieties

Biodiversity is useful to modern agriculture in the following three ways:

(i) As a source of new crops

(ii) As a source of new biodegradable pesticides, and

(iii) As a source material for breeding improved varieties.

Out of several thousand species of edible plants, less then 20 plant species are cultivated to obtain 85 percent of world's food. The three main carbohydrate crops, *e.g.*, wheat, corn and rice, yield nearly 66 percent of the food sustaining the human population.

Fats, oils and fibres etc. are other uses for which more and more new species are required to be investigated.

The commercial, domesticated species are crossbred with their wild relatives to improve their traits. Genes of wild species are used to confer new properties, *e.g.*, disease resistant or improved yield in domesticated species. For example, rice grown in Asia is protected from the four main diseases by genes received from a single wild rice species, *viz.*, *Oryza nivara* from India.

[II] Drugs and Medicines

Biodiversity is a rich source of substances possessing therapeutic properties. A number of important pharmaceuticals have originated as plant based substances. Some plant-derived substances developed into valuable drugs include quinine (*Chinchona ledgeriana*), morphine (*Papaver somniferum*) which used to treat malaria; taxol-an anticancer drug obtained from the bark of the yew tree (*Taxus brevifolia, T. baccata*). A plant rosy periwinkle (*Catharantus roseus*) found in Madagascar showed on examination that its extract was found to counteract the reproduction of cancer cells. Research identified the active ingredients as several alkaloids which are now used to prepare the important anti-cancer drugs *viz.*, vincristine and vinblastine. This once obscure plant now allows treatment of several previously incurable cancers and is the basis of multi-million-dollar economy. At present, nearly 25 percent of the drugs in the pharmacy are derived from a mere 120 species of plants. However, throughout the world, traditional medicines make use of thousands of plant species. Plants are also used to manufacture a large number of synthetic products known as ***botanochemicals.***

[III] Aesthetic and Cultural Uses

Biodiversity also possesses great aesthetic value. Examples of aesthetic rewards include gardening, bird-watching, wildlife, pet keeping, ecotourism etc. In the past, people have related biodiversity to the very existence of human race through religions and cultural beliefs. In most of Indian towns and villages, plants like pipal (*Ficus religiosa*), tulsi (*Ocimum sanctum*) and khejri (*Prosopis cineraria*) and a number of other tress are planted which are supposed to be sacred and worshipped by the people. Several birds including eagle and even snake have been considered sacred. Today, we continue to recognise animals and plants as symbols of national pude and cultural heritage.

[IV] Ecosystem Services

Biodiversity is necessary for the sustainable utilisation and maintenance of goods and services from ecological systems, as well as from individual species. These services include maintenance of gaseous composition of the atmosphere, natural pest control, pollination of plants by birds and insects, climate control by forests and oceanic systems, formation and protection of soil, purification and conservation of water, nutrient cycling etc. These ecosystem services cost 16 to 54 trillion (10^{12}) US dollers per annum.

• 2.10. THREATS TO BIODIVERSITY

There are several factors which lead to extinction of species and consequent loss of biodiversity. These factors are described as follows.

[I] Habitat Loss and Fragmentation

The destruction of habitats is the primary reason for the loss of biodiversity. When people cut down trees, fill a wetland, plough a grassland or burn a forest, the natural habitat of a species is either destroyed or changed. These changes can kill or force out many plants, animals and micro-organisms and disrupt complex interactions among the species. A forest patch surrounded by plantations, orchards, croplands or urban areas is an example of fragmented habitats. When the fragmentation of a large forest tract occurs, the species occupying deeper parts of forests are the first to disappear. Overexploitation of a particular species tends to reduce the size of its population to an extent that it becomes vulnerable to extinction.

[II] Disturbance and Pollution

Natural disturbances like fire, tree fall and defoliation by insects affect the communities. Man made disturbances differ from natural disturbances in intensity, rate and spatial extent. For example, man, by using fire quite frequently may alter the species richness of a community. Then, some new human impacts never faced by biota are experienced, *e.g.*, the vast number of synthetic compounds, large releases of radiations or spillover of oil in sea. These impacts change the habitat quality.

Pollution may reduce and eliminate populations of sensitive species, for example, pesticide linked decline of fish eating birds and falcons. Lead poisoning also causes mortality of several species like ducks, sorans, cranes as they take in the spent shotgun pellets that fall into the lakes and marshes. Eutrophication (nutrient enrichment) of water bodies appreciably reduces the species diversity.

[III] Introduction of Exotic Species

The new species which enter a geographical region are known as **exotic** or **alien species**. Introduction of such invasive species may allow the disappearance of native species through changed biotic interactions. Exotic species are supposed to be second only to habitat destruction as a major cause of extinction of species. Exotic species have large impact especially in island ecosystems, which harbour much of the world's threatened biodiversity, as understood by following examples.

(i) Water hyacinth clogs lakes and rivers thus threatening the survival of several aquatic species in lakes and river flood plains in several tropical countries, including India.

(ii) Nile perch, an exotic predatory fish introduced into lake Victoria (South Africa) threatens the entire ecosystem of the lake by destroying several native species of the small *Cichlid* fish species that were endemic to this freshwater aquatic system.

(iii) *Lantana camara* which invaded a number of forest lands in different parts of India has strongly competed with the native species.

[IV] Extinction of Species

It is well known that extinction can be a natural phenomenon. Species have disappeared and new ones have taken their place over the long geological history of the earth. There are mainly three types of extinction processes.

(i) Natural extinction : Most of the species that have ever lived on earth are now extinct, having disappeared naturally for some reason or the other. Perhaps they could not cope with changes in their inorganic or biotic environment. This loss of species which occurred in the geological past at a very slow rate, is known as natural or background extinction.

(ii) Mass extinction : There have been several periods in the earth's geological history when large number of species may have succumbed to some catastrophic event such as a meteorite impact. Mass extinctions occur in millions of years.

(iii) Anthropogenic extinction : An increasing number of species are disappearing from the face of the earth due to human activities. This man made mass extinction represents a very severe depletion of biodiversity, mainly because it is occurring within a short interval of time. The most important causes of extinction have been the conversion of natural ecosystems to agricultural and urban landscapes, the introduction of alien predators, competitors, herbivores and diseases and to some extent, aboriginal overhunting of some species of birds.

• 2.11. ENDANGERED AND ENDEMIC SPECIES

A species population has a dimension in space, called a range and a dimension in time. The population extends backwards in time, merging with other species populations much like the branches of a tree. The population has the potential to extend forward in time, but various factors may prevent the perpetuation of the species. When the continued existence of a

species is in question, it is regarded as an **endangered species.** This causes great concern to conservationists, especially when the species is the only representative of its genus or family, as is the case with the giant panda. A species found in a very restricted geographic range is **endemic** or narrowly endemic and is at special risk of becoming extinct. Extinction results from an imbalance between a species and the environment in which it is living.

The characteristics of species particularly susceptible to extinction are :

(i) Large body size, *e.g.*, Bengal tiger, lion and elephant

(ii) Small population size

(iii) Low productive rate, *e.g.*, Blue whale and Giant panda.

Feeding at high trophic levels in the food chain, *e.g.*, Bengal tiger and Bald eagle, fixed migratory routes and habitat, *e.g.*, Blue whale and Whooping crane and localised and narrow range of distribution, *e.g.*, many island species, woodland caribou also make the species susceptible to extinction.

Species richness varies with the type of region and it is especially diverse in areas of warm or wet places, such as tropical forests. Many biologists are concerned that the unprecedented destruction of tropical forests is forcing to extinction of species that have not even been discovered. When a species is lost, it is lost forever, and with it the tremendous potential, especially in medicine of that species' contributions to the world.

[I] IUCN Red List Categories

The World Conservation Union, formerly known as International Union for the Conservation of Nature and Natural Resources (IUCN) has given eight Red List categories of species that are facing the risk of extinction. These categories are :

(i) Extinct (ii) Extinct in the wild

(iii) Critically endangered (iv) Endangered

(v) Vulnerable (vi) Lower risk

(vii) Data deficient (viii) Not evaluated.

It is important to note that the Red List aims to provide information about the urgency and scale of conservation problems to the public and policy makers. The uses of the Red List are :

(a) Developing awareness about the importance of threatened biodiversity.

(b) Identification and documentation of endangered species.

(c) Defining conservation priorities at the local level and guiding conservation action.

(d) Providing a global index of the decline of biodiversity.

The species which are threatened with extinction are included in vulnerable, endangered or critically endangered species. Species with small world populations that are not at present vulnerable or endangered but are at risk are known as **rare.** These species are usually localised within the restricted geographical areas or habitats or are thinly scattered over a more extensive area.

[II] Status of Threatened Species

Nearly 11,046 species (5,485 animals and 5,611 plants) are listed as threatened (critically endangered , endangered or vulnerable) on the 2000 Red List. Of these 1,939 are listed as critically endangered which include 1,014 plants and 925 animal species. In India, according to Red List, 44 plant species are critically endangered, 113 endangered and 87 vulnerable. Among animals, the numbers are 18, 54 and 143, respectively. The following table shows some examples of threatened species in India.

Table 1.

Category	Plants	Animals
(1) Critically endangered	Berberts nilghiriensis	Sus salvanius (Pigmy hog)
(2) Endangered	Bentinckia nicobarica	Allurus fulgens (Red panda)
(3) Vulnerable	Cupressus cashmeriana	Antilope cervicapra (Black buck)

• 2.12. CONSERVATION OF BIODIVERSITY

We know that ecosystems undergo change due to pullution, invasive species, overhunting, overexplotation by humans, erosion and nutrient cycling, productivity and climate change. The world has started to recognise that diversity at all levels-gene pool, species and biotic community—is important and needs to be conserved. We have a moral duty to pass our planet in a good health to our future generations from the aesthetic and economic benefits that they can derive from biodiversity. The most effective and efficient method for conserving biodiversity is to prevent further destruction or degradation of habitats by us. We need more knowledge to conserve biodiversity in reduced space and under increased pressure of human activities. We have two basic strategies of conserving biodiversity, *i.e., in situ* (on site) and *ex situ* (off site) conservation strategies.

[I] *In Situ* Conservation Strategies

The *in situ* conservation strategies lay emphasis on protection of total ecosystems. The *in situ* approach includes protection of a group of typical ecosystems through a network of protected areas.

(1) Protected areas : The protected areas are areas of land and/or sea which are dedicated to protection and maintenance of biological diversity and of natural and associated cultural resources. These are managed by legal or other effective methods. The National Parks and Wildlife Sanctuaries are some examples of protected areas. National Parks are

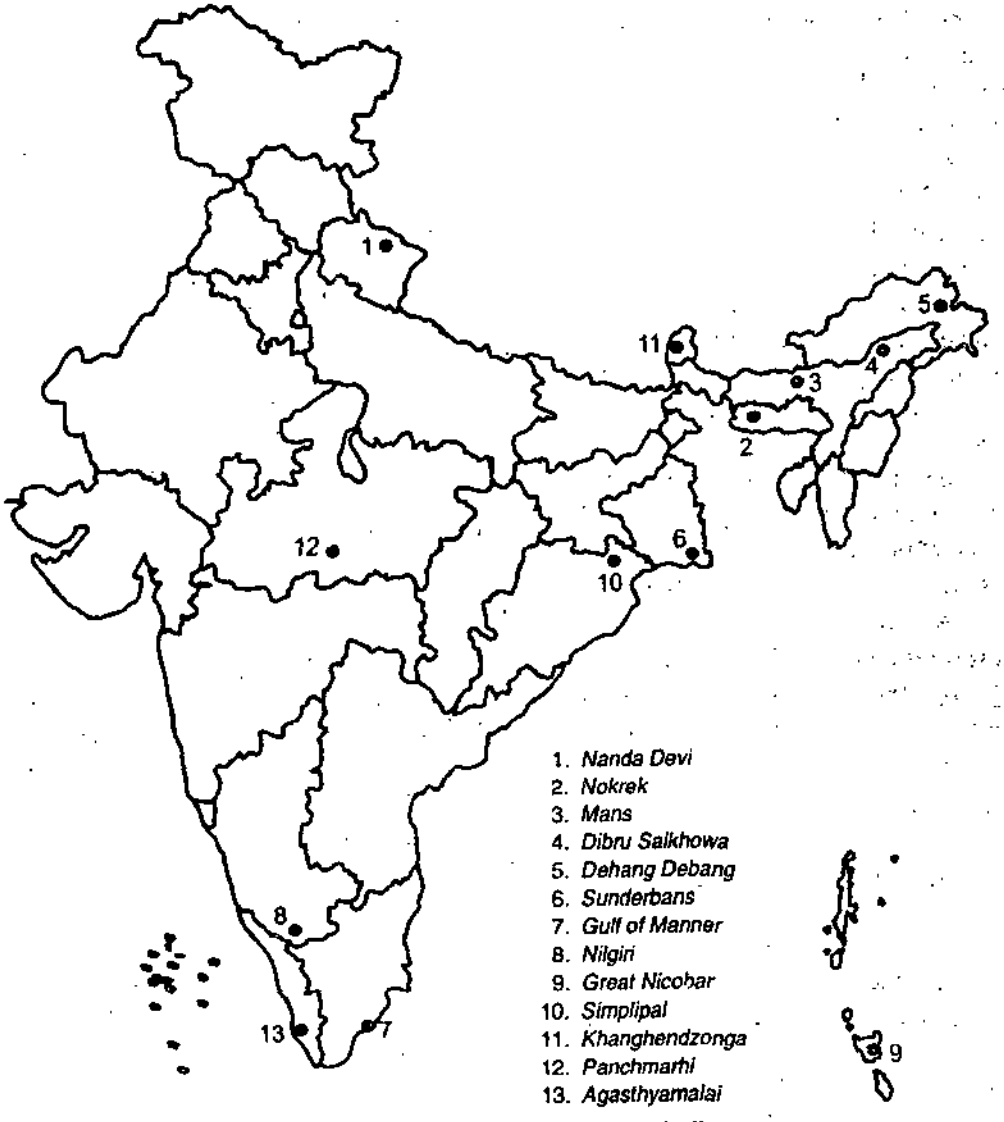


Fig. 26. The biosphere reserves in India.

typically large areas that are mostly undisturbed by human occupation or exploitation. They are characterised by spectacular scenery, abundant wildlife, unique geological features or interesting cultural or historic sites. Activities consistent with typical National Park management include hiking, camping, picnicking, wildlife observation, and photography. Fishing is usually allowed, but hunting is prohibited. The earliest National Parks, *Yellowstone National Park'* (USA, 1872) and the *'Royal'* near Sydney (Australia), were chosen because of their scenic beauty and recreational activities. As of 2002, India has 581 protected areas (89 National Parks and 492 Wildlife Sanctuaries) covering 4·7 percent of the land surface, as against 10 percent internationally suggested norm. The Jim Corbett National Park was the first National Park set up in India.

Main Benefits of Protected Areas : These are,

(a) Maintaining viable populations of all native species and sub-species.

(b) Preventing human caused introduction of alien species.

(c) Maintaining the number and distribution of habitats and communities and conserving the genetic diversity of all the present species.

(d) Making it possible for species or habitats to shift in response to environmental changes.

(2) Biosphere reserves : A special category of protected area of land and/or coastal environments, wherein people act as an integral part of the system is known as ***biosphere reserves.*** Biosphere reserves are representative examples of natural biomes and have special biological communities. In 1975, **UNESCO's Man and Biosphere Programme** gave the concept of biosphere reserves. It deals with the conservation of ecosystems and the genetic resources contained therein. Till May 2002, there were 408 such reserves situated in 94 countries. India has 13 biosphere reserves shown in figure (26). In India, these reserves are notified as National Parks.

A biosphere reserve consists of core, buffer and transition zones as shown in figure (27). The **core** or **natural zone** contains an undisturbed and legally protected ecosystem. The **buffer zone** surrounds the core area and accommodates a greater variety of resource use strategies and research and educational activities. The outermost part of the biosphere reserve, *i.e.*, **transition zone** is an area of active cooperation between reserve management and the local people, where activities like settlements, forestry, cropping and recreation and other economic uses continue to be carried out in harmony with conservation goals. The main features of biosphere reserves are as follows :

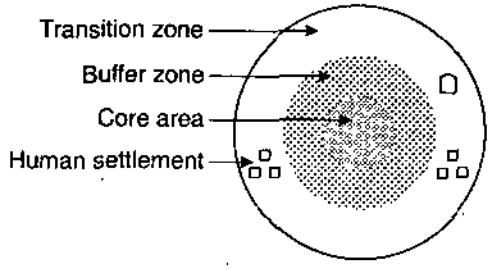


Fig. 27. The zonation in terrestrial biosphere reserve.

(i) Conservation. Biosphere reserves ensure the conservation of ecosystems, species, landscapes and genetic resources.

(ii) Development. Biosphere reserves promote economic development which is culturally, socially and ecologically sustainable.

(iii) Scientific research monitoring and education. The aim of biosphere reserves is to give support for research, monitoring, education and exchange of information related to local, national and global issues of conservation and development.

(3) Sacred forests and sacred lakes : In India and some Asian countries, the traditional strategy for the protection of biodiversity is in the form of ***sacred forests.*** Sacred forests are forest patches of different areas protected by tribal communities due to their religious sanctity. Such forests represent islands of *pristine forests*, *i.e.*, most undisturbed forests without any human effect and are free from all disturbances, though these are frequently surrounded by highly degraded landscapes. In India, sacred forests are situated in Karnataka, Meghalaya, Kerala, Maharashtra etc. These serve as refugia for a number of rare, endangered and endemic taxa.

Similarly, several water bodies, *e.g.*, lakes (Khecheopalri lake in Sikkim) have been treated as ***sacred lakes*** by the people. This leads to the protection of flora and fauna.

[II] *Ex Situ* Conservation Strategies

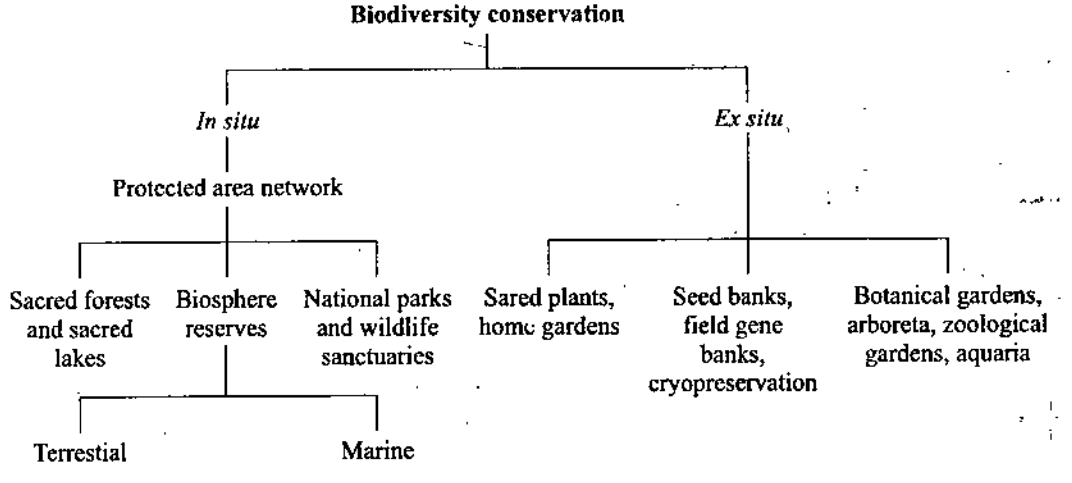
The *ex situ* conservation strategies include zoos, botanical gardens, conservation stands, and gene, pollen, seed, seedling, tissue culture and DNA banks. The easiest method to store germplasm of wild and cultivated plants is the seed gene banks, where they are kept at low temperature in cold rooms. In field gene banks, we can carry out the preservation of genetic resources under normal growing conditions.

The *vitro* conservation, especially by ***cryopreservation*** in liquid nitrogen at –196.χ9C, is mainly useful for conserving vegetatively propagated crops like potato. In cryopreservation, the material is stored at ultra-low temperature either by very rapid cooling (used for storing seeds) or by gradual cooling and simultaneous dehydration at low temperature (used for tissue culture). The material can be stored in compact, low maintenance refrigeration units for quite a long interval of time.

The biological diversity can be conserved in botanical gardens and this process is already in practice. There are more than 1500 botanical gardens and arboreta (botanical gardens where specific tree and shrub species are cultivated) in the world containing more than 80,000 species. Several botanical gardens have seed banks, tissue culture facilities and other *ex situ* methods. Similarly, in more than 800 professionally managed zoos in the world, there are 3,000 species of birds, mammals, reptiles and amphibians. Several zoos have well developed captive breeding facilities.

The conservation of wild relatives of crops plants and the *ex situ* conservation of crop types or cultures of micro-organisms provides breeders and genetic engineers with a ready source of genetic substance. The plants and animals conserved in botanical gardens, arboreta, zoos and aquaria can be employed to restore degraded land, reintroduce species into wild and restock depleted populations.

The biodiversity management systems for conserving biodiversity in India can be summarised as follows :



• 2.13. HOT SPOTS OF BIODIVERSITY

Biodiversity is not evenly distributed across the geographical regions of the earth. Certains areas of the world are the **mega divrsity areas** where a very large number of species are found. For example, India accounts for only 24 percent of the land area of the world, but it contributes nearly 8 percent species to the **global diversity**.

Norman Myers (1988) designated priority areas for *in situ* conservation and called them **hot spots** The hot spots are the richest and the most threatened reservoirs of plant and animal life on earth. The main criteria for selecting a hot spot are:

(i) Number of endemic species, *i.e.*, species which are found nowhere else, and

(ii) Degree of threat which is measured in terms of habitat loss.

Twenty five terrestial hot spots for conservation of biodiversity have been identified worldwide. Their approximate locations are:

Tropical Andes, Mesoamerica, Caribbean, Brazil's Atlantic Forests, Choco/Darien/ Western Ecuador, Brazil's Cerrado, Central Chile, California Floristic Province, Madagasear, Eastern Arc and Coastal Forests of Kenya/Tanzania, West African Forests, Cape Floristic Province, Succulent Karoo, Mediterranean Basin, Caucasus, Sundland, Wallacea, Philippines, Indo-Burma, South Central China, Western Ghats/Sri Lanka, Southwest Australia, New Celedonia, New Zealand, Polynesia/Micronesia.

Tropical forests appear in 15 hot spots, Mediterranean type areas in 5 and 9 hot spots are mainly or completely made up of islands. 16 hot spots are in the tropics. Nearly, 20 percent of the human population lives in the hot spot areas.

Out of the total 25 hot spots of the world, two (Western Ghats and Eastern Himalayas) are found in India and these extend into the neighbouring countries. These areas are rich in flowering plants, reptiles, amphibians, swallow tailed butterflies and some mammals and also exhibit a high degree of endemism.

The Western Ghat region lies parallel to the western coast of Indian peninsula for nearly 1600 kms in Maharashtra, Karnataka, Tamilnadu and Kerala. The forests at low elevation (500 m above sea level) are mostly evergreen, while those found at 500–1500 m above sea level are generally semi-evergreen. The Agasthyamalai hills, the Silent Valley and the new Amambalam Reserve are the two main centres of diversity.

The eastern Himalayan hot spot extends to the north-eastern India and Bhutan. The temperate forests are located at altitudes of 1780–3500 meters. Many deep and semi-isolated valleys found in this area are enormously rich in endemic plant species. The numerous primitive angiosperm families, *e.g.*, *Magnoliaceae* and *Winteraceae* and primitive genera of plants like *Magnolia* and *Betula* besides rich diversity of flowering plants and active centre of evolution are found in eastern Himalaya.

2.14. BIODIVERSITY AT GLOBAL, NATIONAL AND LOCAL LEVELS

For 12 days in June 1992, more than 35,000 environmental activists, politicians and business representatives along with 9000 journalists, 25,000 troops and uncounted vendors, taxi drivers and assorted others converged on Rio de Janeiro, Brazil for the **United Nations Conference on Environment and Development**. Known as the **Earth Summit**, this was the largest environmental conference in history. In fact, it was probably the largest non-religious meeting ever held. The convention has three main objectives :

(i) Conservation of biological diversity

(ii) Sustainable use of biodiversity

(iii) Fair and equitable sharing of benefits arising out of the utilisation of genetic resources.

The **World Conservation Union** and the **World Wide Fund for Nature** (WWF) support projects world wide. WWF has articulated nine goals that guides its work. These are :

(1) to protect habitat;

(2) to protect individual species;

(3) to promote ecologically sound development;

(4) to support scientific investigation;

(5) to promote education in developing countries;

(6) to provide training for local wildlife professionals;

(7) to encourage self sufficiency in developing countries;

(8) to monitor international wildlife trade;

(9) to influence public opinion and the policies of governments and private institutions.

Indian region has also contributed to global biodiversity. India has 167 cultivated species and 320 wild relatives of crop plants. It is the centre of diversity of animal species

(zebu, mithum, chicken, water buffalo, camel), crop plants (sugarcane, rice, tea, banana, millet), fruit plants and vegatables (mango, cucurbits, jackfruit), edible diascoreas, alocasia, colocasia; spices and condiments (cardamom, ginger, black pepper, turmeric), and bamboos, brassicas and tree cotton. India has also a secondary centre of domestication of plants (tobacco, potato and maize) and some animals (horse, sheep, goat, cattle, donkey and yak).

The land races and diverse food and medicinal plants, animals are also being conserved successfully by the tribal people and women working as individuals or with NGOs. The women, in particular, play an important role in the conservation of agrobiodiversity. In India, a programme has started to develop a system of community registers of local informal innovations related to the genetic resources and natural resource management.

SUMMARY

- Ecosystem is defined as any unit that includes all of the organisms, *i.e.*, the community in a given area interacting with the physical environment so that a flow of energy leads to clearly defined trophic structure, biotic diversity and material cycles, *i.e.*, exchange of materials between living and non-living parts, within the system.
- Ecosystem has two main parts, *viz.*, abiotic or non-living component and biotic or living component.
- Food chain is defined as the transfer of food energy from the producers through a series of organisms (herbivores → carnivores → decomposers) with repeated eating and being eaten.
- A network formed by interconnecting food chains is called a food web.
- The total mass of organisms is called biomass.
- The biomass at the time of sampling is known as standing biomass or standing crop biomass.
- Group of different kinds of population in the area are together known as a community.
- The successive replacement of communities in an area over a period of time is called ecological or biotic succession.
- Biodiversity means the totality of genes, species and ecosystems of a region.
- There are three levels of diversity, *viz.*, genetic, species and community diversity.
- If the continued existence of a species is in question, it is known as an endangered species.
- A special category of protected area of land and/or coastal environments, wherein people act as an integral part of the system is known as biosphere reserves.
- A biosphere reserve consists of core, buffer and transition zones.

Student Activity

1. Mention two functions of an ecosystem.

2. Explain grazing food chain.

3. Define pyramid of biomass.

4. What are biosphere reserves?

5. Name the type of extinction processes.

6. Explain genetic diversity.

7. Define alpha, beta and gamma diversity.

• TEST YOURSELF

Answer the following questions :

1. Define an ecosystem. Give its classification
2. What is the structure of an ecosystem?
3. Explain the functions of an ecosystem.
4. Write explanatory notes on the following
   (i) Producers (ii) Consumers
   (iii) Decomposers (iv) Food chain
   (v) Food web (vi) Ecological pyramids
5. What is ecological succession. Explain.
6. Discuss the energy flow in an ecosystem.
7. Mention the differences between grazing and detritus food chains.
8. Describe the single channel energy flow model.
9. Discuss the Y-shaped energy flow models.
10. Define food chain. Name and explain various types of food chains with suitable examples.

11. Describe the features, structure and functions of the following ecosystems :
(i) Forest ecosystem (ii) Desert ecosystem
(iii) Pond ecosystem (iv) Ocean ecosystem
(v) Lake ecosystem

12. Mention the abiotic and biotic components of the following ecosystems :
(i) Grassland ecosystem (ii) Forest ecosystem
(iii) Aquatic ecosystem (iv) Marine ecosystem

13. What is a food chain? Explain with an example.

14. Define food web. Describe the pathways shown by food webs.

15. What is biodiversity? Why has it become so important recently?

16. Define species, genetic and ecosystem biodiversity.

17. Mention the productive and consumptive uses of biodiversity.

18. Describe the biogeographical regions of India.

19. What is exotic species?

20. What kinds of threats to the biodiversity may lead to its loss?

21. Write short notes on the following:
(a) Protected areas (b) Biosphere reserves
(c) Hot spots of biodiversity (d) *IUCN Red List*
(e) Earth Summit (f) *Ex situ* conservation
(g) *In situ* conservation (h) National parks

22. Enumerate different biogeographic zones of India and explain the characteristics of each.

23. What do you understand by 'Hot spots of Biodiversity'. Name and briefly describe, alongwith vital signs, the two hot spots of biodiversity that extend into India.

24. Write short notes on any two of the following :
(i) Rare species and threatened species.
(ii) Poaching of wildlife.
(iii) *In situ* conservation of biodiversity.

25. The food chain which starts from the living green plants, goes to grazing herbivores and on to carnivores is known as :
(i) Grazing food chain (ii) Detritus food chain
(iii) Food web (iv) Non-grazing food chain

26. Decomposers are also known as :
(i) Macro consumers (ii) Microconsumers
(iii) Primary macroconsumers (iv) Consumers

27. Nutrients present in soil and the aerial environment are called :
(i) Biotic components (ii) Abiotic components
(iii) Primary consumers (iv) Secondary consumers

28. Fill in the blanks :
(a) Hydrarch type of succession occurs in ..... bodies.
(b) Producers, consumers and decomposers are different ..... components of a desert ecosystem.
(c) When a species disappears from the face of the earth due to human activities, it is called ..... extinction.

ANSWERS

25. (i), **26.** (ii), **27.** (ii), **28.** (a) water, (b) biotic, (c) anthropogenic.

UNIT

3

ENVIRONMENTAL POLLUTION

STRUCTURE

- Pollution and Pollutant
- Soil Pollution
- Thermal Pollution
- Disaster Management
- Summary
- Water Pollution
- Marine Pollution
- Nuclear Hazards
- Pollution Control
- Student Activity
- Air Pollution
- Noise Pollution
- Solid Waste Management
- Test Yourself

LEARNING OBJECTIVES

After studying this chapter you will learn about different types of pollution such as water, air, soil, marine, noise, thermal and nuclear pollution. You will also learn about the steps taken to control these types of pollution. You will also learn about solid waste and disaster managements.

3.1. POLLUTION AND POLLUTANT

Pollution occurs when human's wasteloads on the water, land and air overwhelm the natural process of assimilation of such wastes. Pollution of our environment has become a serious matter. The water, light, air and temperature conditions, soil, forests and other useful plant communities, mineral resources, cattle and animals etc. form the ***human environment.*** In other words, ***any change which adversely influences the biological and non-biological equilibrium of the environment is called pollution***. The Science Advisory Committee of U.S.A. (1965) said that, ***"environmental pollution is the undesirable change of our surroundings wholly or largely as a by-product of man's actions, through direct or indirect effects, changes in energy patterns, physical and chemical constitution and abundance of organisms."*** Pollution may also be defined as ***direct or indirect changes in one or more components of the ecosystem which are harmful to the system or at least undersirable for man.***

The substances which cause pollution are called ***pollutants.*** A ***pollutant*** *is a substance (e.g. dust, smoke), chemical (e.g., SO_2) or factor (e.g., heat, noise) that when released into the environment has an actual or potential adverse effect on human interests.* Thus, pollutants are residues of the things we make, use and throw away.*

[I] Kinds of Pollutants

Pollutants can be broadly divided into two types :

(1) Non-degradable pollutants : The substances and poisons like aluminium cans, mercuric, lead, cadmium salts, long chain phenolic chemicals and pesticides like DDT (dichloro diphenyl trichloroethane) that either do not degrade or degrade very slowly in natural environments are *non-degradable pollutants.* They are not recycled in ecosystem naturally, they are accummulated as well as are biologically magnified, *i.e.,* they pass from one biological system to another.

(2) Bio-degradable pollutants : These are domestic wastes that can be readily decomposed under natural processes. When they accummulate, *i.e.,* their input into environment exceeds the decomposition capacity, they create problems, *e.g.,* domestic sewage, heat or thermal pollution.

* Pollution and pollutants increase with a rise in population, which result into smaller available space and an increase in demands per person, so that each throws away more wastes year after year.

[II] Areas of Pollution

From the ecosystem point of view, earth can be divided into three main zones :

(i) Lithosphere : This consists of earth, rocks, mountains etc. From this part, the plants prepare the food from inorganic matter, minerals etc.

(ii) Hydrosphere : This sphere is found at some places in the earth's lithosphere. Water, ponds, lakes, sea, waterfalls are some constituent examples of hydrosphere.

(iii) Atmosphere : This sphere is extended to about 350 km above the earth. It consists of different gases like oxygen (O_2), nitrogen (N_2), carbon dioxide (CO_2), sulphur dioxide (SO_2), water vapours (H_2O) etc. The amounts and ratio of these gases are balanced in atmosphere.

The animals living on earth form the ***biosphere***. It is related to the atmosphere as shown in figure (1). The biosphere is made up of the above areas or zones. For breathing and other different physiological reactions, living animals or people need air and water, respectively. Plants get the mineral salts from the soil of the lithosphere. If pollutants are present in this region, they will naturally affect the living organisms.

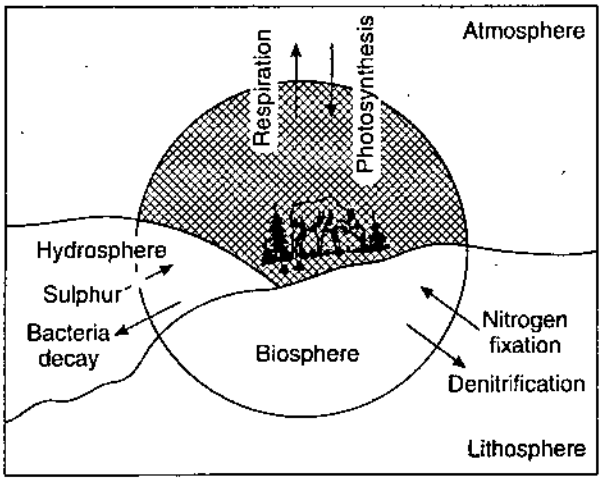


Fig. 1. Relation between biosphere and environment.

[III] Causes of Environmental Pollution

The environment is being polluted everyday. Besides score of reasons, some of the important reasons are listed below :

(1) Increasing concentration of carbon dioxide and other gases : Carbon dioxide content in atmosphere is slowly rising due to the large scale burning of fossil fuels and organic fuels without a corresponding increase in plant production. A rise in carbon dioxide concentration will warm up the earth atmosphere to such an extent as to melt away the polar ice and a rise in the sea level, thus submerging a large number of low lying areas. Moreover, carbon dioxide gas is injurious to human health and it also decreases the oxygen content. Similarly, other gases like sulphur dioxide, nitrogen oxides, ozone etc. made up of complex mixture of hydrocarbons are common gaseous pollutants.

(2) Domestic wastes and sewages : Treated or untreated sewage of boats, ships, municipal boards etc. is poured into water bodies. Many organic wastes are added from slaughter houses, tanneries, canning industries etc. The villagers often wash their animals, clothes and take bath in the same pond. Such water gets polluted. Modern day detergents used for brighter and quicker washing are very slow to get degraded. They accummulate and make water unfit for human and animal use. The sewage consists of faecal matter, urine and kitchen washings etc.

(3) Industrial effluents : These are industrial wastes which are either dumped in the soil or are allowed to pass into water bodies. The effluents consist of heavy metals like lead, copper, zinc, mercury, cadmium etc., cyanides, acids, alkalies, organic solvents etc. Some liquid effluents are commonly passed out into rivers directly or indirectly for disposal. Some

modern industrial complexes like fertilizer and oil factories, petrochemical complex synthetic material plant for fibres, rubber etc. are the chief sources of pollution.

(4) Pesticides and weedicides : A number of chemicals like D.D.T., methoxychlor, phenol, lime, sulphur powder, toxaphene, aldrin, benzene hexachloride etc. are used to kill insects (*insecticides*), fungi (*fungicides*), algal blooms (*algicides*), weed (*weedicides*), rodents (*rodenticides*) to improve crop cultivation, forestry, horticulture and water reservoirs etc. Most commonly used substance is insecticide, which is sprayed over plants in the form of a fine mist or powder. These pesticides accummulate in earth's soil, air, water and pollute them. Thus, they affect other animals, men and even plants,; through different sources. If present in soil, they destroy the organisms responsible for preparing humus. Thus, fertility of the soil decreases.

(5) Automobile exhausts : Life in modern society is marked by an enormous increase in number of automobiles for personal conveyance, goods transport and passenger traffic. The exhaust from the internal combustion engines of the motor vehicle fouls the air, thus making it less healthy to breathe in. They contribute 60% of the air pollution. Diesel and petrol produce similar pollutants in air through the exhausts.

(6) Radioactive substances : Some elements emit during their decay, high energy radiations which remove electrons from stable atoms. Isotopes of those elements that emit such radiations are known as ***radioactive isotopes*** **or** ***radionuclides***. These escape frequently into the atmosphere. Wastes from nuclear reactors add such isotopes to rivers, water reservoirs, etc. After the nuclear test, the '***fall out***' adds large amounts of such isotopes in the air. These radioactive isotopes accummulate through contaminated food, water or air. They are said to cause cancer, congenital deformities and abnormalities in the organs.

3.2. WATER POLLUTION

Water is the most abundant resource on earth. Worldwide there is about $1 \cdot 5 \times 10^{21}$ litres of water. Most of this water is contained in seas and oceans. There are two main sources of water. These are :

(1) Surface sources : Sea, rivers, ponds, lakes etc., are surface sources of water.

(2) Underground sources : Wells, tubewells, hand-pumps are underground sources of water.

In India, about 15 percent of the population get clean drinking water, while the rest 85 percent get water from polluted lakes, rivers, wells, etc. We know that our life depends on water and human needs water for his drinking and other domestic and industrial processes. Rivers are the major source of drinking water for people in the rural areas. There rivers are becoming increasingly polluted by city wastes and the villagers are left with no choice but to use the contaminated water. However, water pollution can be defined in a number of ways as follows :

(i) Water pollution means the introduction into natural water of anything that to them looks to be foreign.

(ii) Water pollution is the addition of something to water which changes its natural qualities.

(iii) Water pollution means an undesirable change in the physical, chemical or biological characteristics of water, that may harmfully affect the human life, our industrial processes, living conditions etc.

[I] Sources of Water Pollution

Water is polluted mainly by domestic sewages, wastes, industrial wastes and effluents, pesticides and herbicides, radioactive wastes, thermal emissions etc.

(1) Domestic wastes and sewages : These are important pollutants of wells, ponds and rivers which are our principal sources of drinking water. The villagers often wash their animals, clothes and take bath in the same pond, whereby the water gets polluted. The rivers and wells are polluted with our own excreta, besides those of animals and birds.

(2) Domestic detergents : Modern day detergents used for quicker and better washing are very slow to get degraded. Therefore, they accummulate and make the water unfit for human and animal use. The phosphates present in detergents are responsible for the growth of algae and when algae die, they release their components back into the water and thus they become pollutants. In water, they give ammonia and amino acids.

(3) Pesticides and herbicides : The desire of man to increase the production of grain and other agricultural products, have made the use of pesticides and herbicides even more popular. These are sprayed on plants to kill harmful pests and weeds. These then percolate through soil and get dissolved in soil water, thus polluting it. These pesticides etc., are also washed down with rain water and so rivers, streams, sea etc., get polluted.

(4) Industrial effluents : Most of the effluents from different industries are commonly passed out into rivers directly or indirectly for disposal. The effluents consist of heavy metals like mercury, copper, zinc, lead, cadmium etc., cyanides, thiocyanates, acids, alkalies, organic solvents etc. Metallic pollutants are very harmful for human health.

(5) Fuel gases : Certain fuels like coal, petrol, diesel etc., when burnt give poisonous gases. These gases are dissolved by rain water and are taken into rivers, ponds etc. The water thus gets polluted.

(6) Oil : At many places, petroleum is extracted from the area of ocean or sea. Further, it is transported from one country to another through sea. After unloading, the tankers are washed in sea before being filled again. Thus, the oil spills or slicks are quite common in the sea, especially near the ports and shore lines. Refineries also discharge a huge amount of oil present in their effluents into rivers.

River pollution by oil occurs through the discharge of industrial wastes from metallurgical industries, engineering industries and garages. Boats, tanks, barges etc. also introduce oils into rivers and canals.

The sources of oil pollution of sea may be considered to be due to the following factors :

(i) Discharge of oily wastes such as tank washings etc.

(ii) Maritime accidents which result in the release of oils.

(iii) Accidental spoilages occurring due to the incorrect operation of valves etc. on ship board or at oil terminals.

(iv) Spillages while transferring oil or cargo from ship to ship or ship to the shore.

These oils are mainly constituted with hydrocarbons and the presence of oil even in trace amounts is detectable by the characteristic fluorescence.

(7) Radioactive wastes : These days, radioactive substances are used for preserving food, heating, generating power, in medicines etc., besides being used to prepare bombs. The wastes of radioactive substances from nuclear reactors, hospitals etc., dissolve in water. Moreover, the nuclear tests are generally carried out in sea, whereby the radiations emitted by these tests pollute water.

(8) In the purification of water, a number of purifiers are used. These are generally poisonous. If they are mixed in an appreciable amount, they pollute the water.

[II] Types of Water Pollution

The polluted water can be divided into the following categories :

[A] Physical Pollution

(1) Thermal pollution : Thermal pollution is caused by the production of hot effluents, hot air and hot water. Hot water is given out in all those industries which employ water as a coolant. Factories which employ steam also give out a lot of hot water. Hot water kills both plants and animals in the area of its discharge. Away from the area of discharge, the temperature of water becomes higher by a few degrees. Warmer water contains less oxygen which increases the biochemical oxygen demand (BOD). BOD is defined as, ***"the quantity of oxygen required for the oxidation of organic matter by bacterial action in presence of oxygen."*** It is a measure of the strength of organic matter in terms of its ability to decrease oxygen in water. Due to less oxygen in water, the rate of decay of organic matter decreases.

Moreover, high temperature denatures enzymes, increases respiration and lowers down the rate of photosynthesis. Therefore, there is a decreased primary production. Most of animals fail to multiply.

(2) Taste and odour : If the water has objectionable taste and foul odour, it cannot be used for drinking purposes. The presence of even 0·1 mg/litre chlorine, 0·001 mg/litre phenol, 0·1 mg/litre detergent can be identified by taste only. Some algae also make the taste and odour of water objectionable. If such contaminated water is passed through activated charcoal, it can be used for drinking purposes.

(3) Colour : Natural water comes through different places, trees, plants etc., and has a light brown colour. But coloured water discharged from industries contains a number of impurities. The colour of water can be removed by passing water through thick surface of activated charcoal.

(4) Foam : Detergents and other substances which have a lower surface tension than water produce foam. The water discharged from paper manufacturing factories produces foam due to the use of synthetic detergents. The foam containing water consists of suspended solid impurities, bacterias etc., which make the water poisonous.

(5) Suspended impurities : The turbidity present in water also produces water pollution. The turbidity is due to the presence of suspended particles. Such impurities can be removed by allowing water to stand at a certain place for a long time, whereby they settle down and can be removed.

(6) Radioactive wastes : The nuclear tests are generally carried out in sea. Due to these tests, the radioactive fall out pollute water.

[B] Chemical Pollution

A number of chemical substances mix and dissolve in water, whereby creating water pollution. These chemical substances may be organic or inorganic, as described below.

(1) Organic pollution : A number of organic substances like fats, fatty acids, carbohydrates, proteins, detergents, pesticides etc. are known as ***organic pollutants.*** When these are present in water, they get decomposed by soil, water and bacterias or enzymes. All these processes involve oxygen, whereby the content of oxygen in water decreases and becomes unfit for fishes and other aquatic animals. Such water is extremely harmful to the plants. Such pollution occurs in water, which is discharged from cane sugar, alcohol industries etc.

(2) Inorganic pollution : The pollution caused by the presence of acids, alkalies, soluble and insoluble salts in water is known as ***inorganic pollution.***

(a) Acids and alkalis : Both organic and inorganic acids are discharged commonly to rivers in the form of industrial effluents. In the manufacture of chlorine, sodium hydroxide and allied chemicals, industries discharge sulphuric acid, while the water discharged from textile, viscose processing, tanning industries contains an excess of alkali. Organic acids are discharged from the manufacture of rayon, fermentation plants, distilleries, dyeing industries, manufacture of leather etc. In electroplating plants, harmful heavy metals and cyanides are used which cause excessive acidity or alkalinity in water of rivers and streams. Such water is quite harmful for aquatic animals and is unfit for drinking.

Since organic acids are mild, they are given less importance regarding pollution aspects and only inorganic acids are studied carefully due to their toxic nature.

(b) Soluble salts : A number of salts, *e.g.*, chlorides, sulphates, carbonates, bicarbonates, phosphates, nitrates, cyanides, sulphides of sodium, potassium, calcium, magnesium, iron, manganese etc., are present in water. If these chemicals are present beyond a certain limit, they pollute water. For example, if the content of chlorine in water is 100 mg/litre or 1000 mg/litre, the water is called ***fresh water*** or ***salty water,*** respectively. If water contains sulphates, carbonates and bicarbonates of calcium or magnesium, it is termed as ***hard water.*** Hard water cannot be used for drinking as well as in boilers. Certain salts of iron, manganese make the water coloured and turbid.

(c) Insoluble salts : Some factories discharge finely divided particles of dust, dirt, calcium sulphate, calcium carbonate. These are insoluble in water but, however, they pollute water.

(d) Poisonous inorganic chemicals : Many industries discharge poisonous chemicals, *e.g.*, heavy metals like mercury, copper, zinc, lead, cadmium etc., ammonia, chlorine, hydrogen sulphide etc.

(i) Mercury : Mercury is released during combustion of coal, smelting of metallic ores, paper and paint industries. It is highly toxic and causes deaths and deformities to workers handling them. It also kills fish, flora and fauna.

(ii) Lead : Lead is mostly used as an anti-knock compound in petrol. It is also released by automobile exhausts. Smelters, chemical and pesticide industries also produce lead. It has mutagenic properties and brings about congenital deformities. Symptoms of lead poisoning include anaemia, loss of appetite and bluish lines around the gums.

(iii) Cadmium : Cadmium ranks next to mercury in its toxicity. It is added to our environment by metal industries, welding and electroplating, phosphate and pesticides industries. It accumulates in kidneys and liver. It brings about hypertension, renal damage, emphysema etc. Once cadmium enters the body, it is likely to remain there. Consumption of cadmium salts causes cramps, nausea, vomiting and diarrhoea.

(iv) Other metals : Other common pollutants of smelters, mining operation, metal industries, electroplating etc. are copper, nickel, zinc etc. They are persistent and settle down in both plant and animal tissues. They bring about change in enzyme functioning, toxaemia, thus bringing about dislocation of healthy metabolic activity.

(v) Inorganic pesticides : These pesticides usually contain sulphur and arsenic. Their continued use is poisonous to both plants and animals. Plants suffering from arsenic toxicity show yellowing, shot holes, premature defoliation etc.

(vi) Chlorine : The presence of excess amount of free chlorine in streams or rivers has to be avoided because of the following reasons :

(a) It is a powerful irritant.

(b) It causes fatal-pulmonary oedema, a disease of lungs in men.

(c) It is corrosive to metals, building structures etc.

(d) It completely destroys the aquatic life including fish.

(vii) Hydrogen sulphide : Sewages containing organic sulphur compounds are decompsed by sulphate reducing bacteria and proteolytic bacteria to form hydrogen sulphide in the absence of oxygen. It is a local irritant and acts as a respiratory depressant causing conjunctivitis, oedema of lungs in men, bronchial irritation. The approximate toxic concentration of hydrogen sulphide to fish has been fixed at 0·5 to 1·0 ppm above which it becomes lethal to fish.

(viii) Fertilizer industries discharge ammonia, which when dissolved in water, makes the latter harmful.

(ix) The other minor gaseous pollutants are carbon monoxide and carbon dioxide. Free carbon dioxide is produced by the action of acid discharges on bicarbonates or by the oxidation of organic matter. Free carbon dioxide is lethal to fish and its eggs. Carbon monoxide present in the effluents from gas works, affect the respiration of fish.

[C] Biological Pollution

Water is also polluted by the presence of bacteria, viruses, algae, fungi, parasites etc. Some unwanted plants and animals also pollute water. This is mainly due to the presence of domestic sewage, agricultural chemicals, pesticides, industrial wastes etc. By the continuous use of such water, a person suffers from a number of diseases like dysentry, jaundice, cholera, typhoid etc.

Biological pollutants may be classified into two groups *viz.*, ***primary pollutants*** and ***corollary pollutants.*** The former pollutants consist of biota that are added to water directly due to man's activities, *e.g.*, pathogenic bacteria or viruses from sewage. The latter pollutants

consist of ingeneous living materials that interfere with the beneficial uses of water, *e.g.*, weeds in irrigation ditches. While primary pollutants have very short life, the corollary pollutants have a longer life. The nature and effects of some of the important primary pollutants such as bacteria, viruses and corollary pollutants such as algae are mentioned below :

(i) Virus : Water polluted by domestic sewage consists of a number of viruses, causing a number of diseases.

(ii) Parasites : The presence of parasites in water causes deformities, malfunctioning of liver, dysentry, skin diseases etc. The parasites increase quite rapidly in artificial lakes, water tanks etc. By drinking such water, earthworms, roundworms, etc. are born in the human stomach.

(iii) Weeds : Fertilizers when mixed with water, produce weeds. These decrease the content of oxygen and are harmful to both plant and animal lives.

(iv) Disease carrying germs : A number of germs like mosquitoes, flies etc. are produced in polluted water or stationary water. These produce a number of diseases like cholera, dysentry, dyptheria etc.

(v) Algae : The algae constitute a group of life forms that may be unicellular or multicellular, motile or non-motile. They belong to corollary pollutants. The green algae produce a naisturtium like odour at high concentration. Apart from odour and taste, algae impart colour and turbidity to water. Algae are indirectly responsible for gastroenteritis. Some algae are deadly poisonous.

[III] Water Pollution in India

Water pollution in India has acquired serious problems. However, institutes like Central Board of Prevention and Control of Water Pollution, Calcutta; National Environmental Industrial Research Institute, Nagpur are doing commendable work in the direction of minimising the water pollution. A number of attempts have been suggested by industries to prevent water pollution. A brief description is given in the following table.

Table 1. Water pollution in major industries and its removal

Industry	Major pollutants	Major methods of removal
1. Steel	Solid suspended particles, ash, highly acidic salts of iron etc.	Flow into ground or rivers etc.
2. Tanning	Organic compounds, salts etc.	Flow into ground or rivers etc.
3. Electroplating	High acidity and alkalinity, poisonous metals.	Flow into sewers, however, these days, the metals are precipitated or reduced.
4. Nitrogenous fertilizers	High alkalinity, excess of ammonia which is harmful for fishes and different types of plant.	Flow into ground or rivers etc.
5. Phosphatic fertilisers	Excess of fluorides.	Flow into ground or rivers etc.
6. Textiles	High acidity, high alkalinity, organic salts and other soluble substances.	Flow into ground, nullahs, rivers etc. after dilution.
7. Distilleries	High alkalinity, organic compounds, coloured and soluble substances.	Flow in grounds, nullahs, river etc. after dilution.
8. Milk	Enzymes, grease, acids, alkalies, foul smelling substances, organic substances.	Flow into fields, nullahs, sewers etc.

From the above table, it can be concluded that most of the industries allow the industrial effluents to flow into rivers, nullahs etc. whereby the water gets polluted. Such water now becomes unsuitable for drinking purposes. Practically, every river, stream, nullah is polluted. Government of India has now started anti-pollution measures to prevent Ganges water from being polluted. In fact, such efforts have started giving results.

[IV] Harmful Effects of Industrial Effluents

(1) Industrial effluents give colour and turbidity to the receiving waters.

(2) Acids and alkalies present in effluent render the water corrosive.

(3) Heavy metals and other toxic substances may kill fish and other aquatic life, animals and vegetables.

(4) The effluents undergo putrefaction to form evil odours and objectionable tastes.

(5) The toxic substances may kill the bacteria and the natural purification processes of the streams are thus inhibited.

(6) Heated effluents discharged into rivers may cause harmful rise in the temperature of the stream and thus ecosystem of the water course may possibly be changed.

(7) Some of the trade substances may contain pathogenic bacteria.

[V] Effects of Water Pollution

(1) Effect on animals : In polluted water, the content of oxygen becomes less. As a result of this, fishes and other aquatic animals experience fatal effects and the water begins to stink. When the suspended impurities settle down at the bottom of rivers, ponds etc., then algae and other aquatic plants are destroyed. Human beings feeding on poisoned animals develop a crippling deformity called ***minimata disease.***

(2) Effect on plant life : If the plants or trees are irrigated with polluted water, then the former get polluted and become diseased. As a result of this, their growth is inhibited. If animals or human beings eat their fruits etc., they cause harmful effects on metabolism.

(3) Effect on human or living beings : If human beings drink polluted water, they suffer from a number of infectious diseases like cholera, typhoid, dysentry, jaundice, diarrhoea and skin diseases. Water polluted by metals may cause congenital deformities, anaemia, loss of appetite, bluish lines round the gums etc.

Table 2. Waterborne diseases transmitted through drinking water and food

Disease	Type of organism	Symptoms and comments
1. Cholera	Bacteria	Severse vomiting, diarrhoea and dehydration, often fatal if untreated, primary process water borne; secondary cases carried by contact with food and flies.
2. Typhoid	Bacteria	Severe vomiting, diarrhoea, inflamed intestine, enlarged spleen, often fatal if untreated; primarily transmitted by water and food.
3. Bacterial dysentry	Several species of bacteria	Diarrhoea, rarely fatal, transmitted through water contaminated with faecal matter or by direct contact through milk, food and flies.
4. Amoebic dysentry	Protozoa	Diarrhoea, possible prolonged transmitted through food, including shell-fish.
5. Paratyphoid	Several species of bacteria	Severe vomiting and diarrhoea, rarely fatal, transmitted through water or food contaminated with faecal matter.
6. Infectious hepatitis	Virus	Yellow jaundiced skin, enlarged liver, vomiting and abdominal pain, often permanent liver damage, transmitted through water and food, including shell-fish foods.

(4) Effect on ecological balance : As polluted water affects plants, animals, human beings, the ecological balance is also disturbed. This produces adverse effect on the environment, *e.g.*, excess of heat or cold, no rainfall on time.

(5) The inorganic acids cause damage to metals or concrete structures, pumps etc. by their corrosive activity. Moreover, they produce hydrogen sulphide gas when they come in contact with sludge and mud of the river.

[VI] Purification of Water for Public Use

The disinfection of water means the destruction of water-borne pathogens like bacteria, viruses and amoebic cysts. The process of disinfection involves the killing of those living

organisms which can spread or transmit infection through or in water. There are several methods for disinfection of drinking water. These are :

(a) Disinfection by light : Sunlight is a natural disinfectant. The ultraviolet light is a good source for this purpose. The common source of UV light is a mercury lamp made of quartz.

(b) Disinfection by heat : The drinking water can be disinfected by heating it to its boiling point.

(c) Disinfection by alkalies and acids : The bacteria die in a very short time in highly acidic or alkaline waters.

(d) Disinfection by surface active chemicals : In this process, detergents, *i.e.*, surface active substances are used.

(e) Disinfection by gases : Ozone is used for disinfecting drinking water in countries like USA, West Germany, France and some African countries. It serves as a disinfectant, removes turbidity and colour producing substances. As ozone is a toxic substance, it is handled very carefully within certain limits.

For routine disinfection and purification of drinking water, chlorine is generally used as it is both efficient and cheap. In India, generally chlorine gas or bleaching powder is used. Besides chlorine, other substances which can be used for disinfection are bromine and iodine.

(f) Disinfection by metal ions : Silver ions are bactericidal and disinfection occurs even if 1 part of silver is present in one hundred million parts of water. Moreover, copper ions and zinc ions are also used, as they kill a number of viruses and other micro-organisms.

Leaves of tulsi are also responsible of killing viruses and other micro-organisms both in water and milk.

(g) Purification by coagulation : Several coagulants like alum, ferric chloride, lime are used, whereby all colloidal particles present in drinking water coagulate. They settle down and thus water can be decantated.

(h) Potassium permanganate is a good disinfectant and an oxidising agent. It is added to water of tube well etc. so that bacteria in water die. But being costlier than chlorine, it cannot be used on a commercial scale.

• 3.3. AIR POLLUTION

A few billion years ago, the atomosphere of the earth consisted of ammonia, methane and water vapour. Through an oxygen revolution brought about by the evolution of photosynthetic reaction, the atmosphere became rich in oxygen. Dry air has N_2 (79%), O_2 (20.9%), CO_2 (0.03%) and the rest are other gases. The natural air contains trace amounts (about 1 ppm) of methane (CH_4), sulphur dioxide (SO_2), ammonia (NH_3), hydrogen sulphide (H_2S), carbon monoxide (CO), hydrogen (H_2), argon (A) and variable amounts of dust particles.

Table 3. Composition of pure and dry atmospheric air

Component	Percent by volume	Percent by weight
Nitrogen	78.08	75.54
Oxygen	20.94	23.14
Carbon dioxide	0.033	0.05
Methane	0.00015	0.000031
Hydrogen	0.00005	0.00004
Ozone	0.00005	0.0000017
Helium	0.000524	0.0007
Argon	0.934	1.27

The human life has added a large number of pollutants in the atmosphere, the important being SO_2, CO, hydrocarbons, oxides of nitrogen, solid particles and heat. With so many

industries coming up, the presence of obnoxious gases and metal particles have increased tremendously in the atmosphere.

So, besides oxygen, if the air contains gases more than the recommended proportion, it becomes unfit for respiration. So, ***air pollution is the increase in concentration of undesired gases in the atmosphere.*** On this ground, air pollution may be described as ***the imbalance in quality of air so as to cause ill effects.*** The main constituents of air are oxygen, nitrogen, carbon dioxide and water vapour, and their cycles are always operative in nature so that the atmosphere is not polluted. but because of the addition of air pollutants, the atmosphere gets polluted.

[I] The Carbon Dioxide Cycle

It consists of several sub-cycles. Carbon, an essential component of all living things is cycled into food webs from the atmosphere, as shown in figure (2). Green plants obtain CO_2 from air and through photosynthesis incorporate carbon into food substances. A portion of the carbon in food transforms it back into CO_2 as a by-product of respiration. This carbon dioxide is then released to the atmosphere. Dead plants and animal materials buried under earth's surface are changed into coal, oil and natural gas by heat and compression. When these materials known as ***fossil fuels*** are burned, energy is released and the stored carbon combines with oxygen in the air to form carbon dioxide which enters the atmosphere.

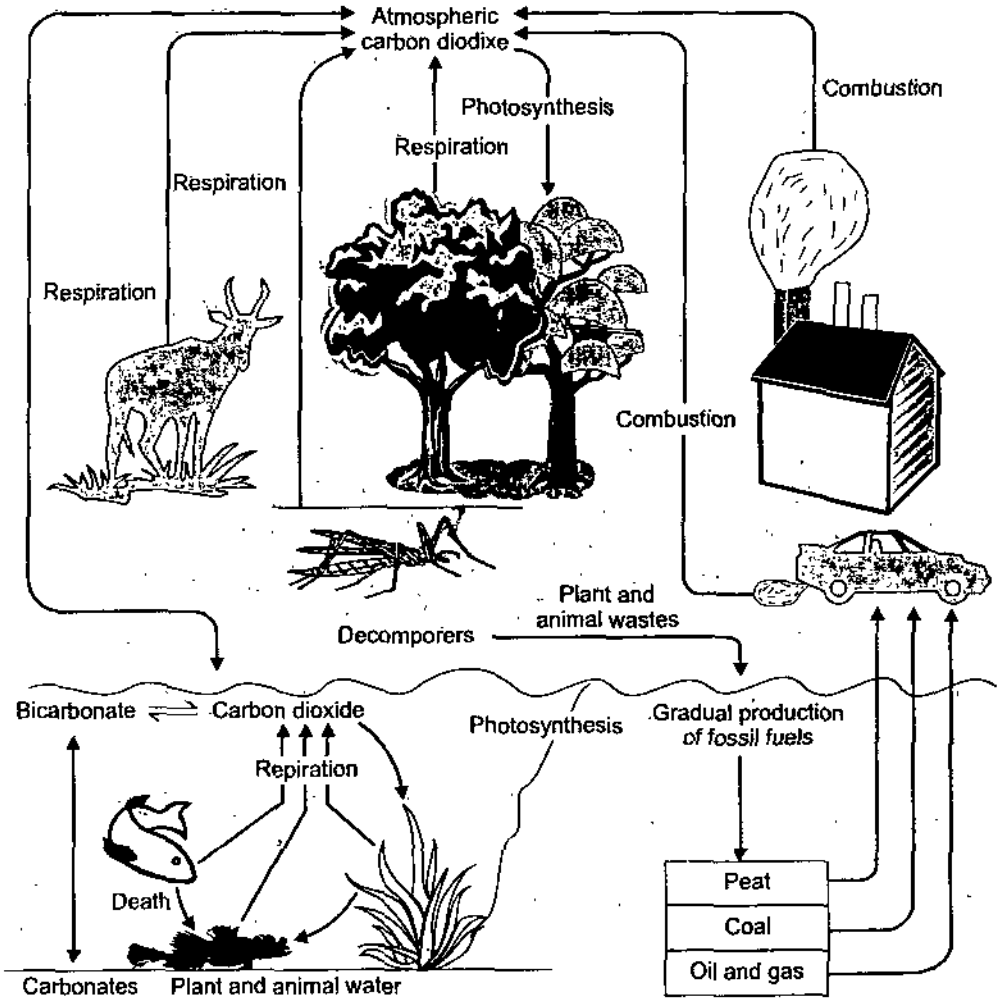


Fig. 2. The carbon dioxide cycle.

[II] The Nitrogen Cycle

As a component of protein, nitrogen is essential to all forms of life. Air cannot be used directly by plants as a nitrogen source. In nature, through two major processes, nitrogen gas is changed into forms that plants can use. These are shown in figure (3). One of these

processes is ***atmospheric fixation,*** which occurs during electrical storms. The electrical energy in lightening makes nitrogen gas to react with oxygen gas in atmosphere to form nitrate (NO_3^-). This form of nitrogen is captured by falling raindrops and carried to the soil, where it can be taken up by plants.

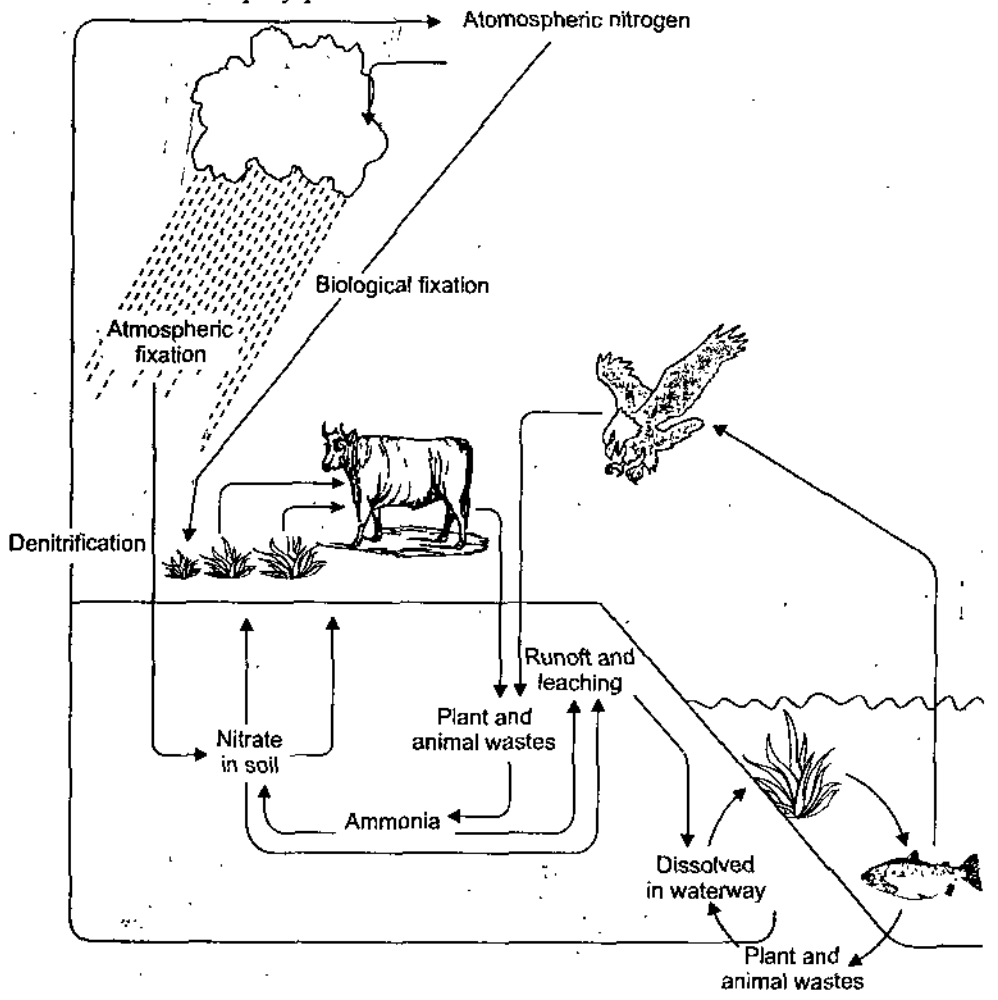


Fig. 3. The nitrogen cycle.

The other process that makes nitrogen available to plants is ***biological fixation.*** Within soil, special types of micro-organisms combine nitrogen gas with hydrogen to form ammonia (NH_3). This ammonia is acted upon by other specialized bacteria and is eventually changed into nitrates.

Nitrates are easily taken up by plant roots. When plants and animals die and decompose, nitrogen is again converted into ammonia, in which it returns to the soil. Animal wastes, rich in urea, are other major recycling routes. Organic nitrogen compounds, *e.g.*, proteins and urea are converted into ammonia by another group of bacteria. Once the ammonia returns to the soil, it is changed to nitrate by microbial action and is taken up by plants and recycled through food webs.

Ammonia and nitrates are lost from terrestrial ecosystems through denitrification and transport by water. In the former, nitrates are changed back into nitrogen gas which escapes from the soil into the atmosphere. In the latter process, nitrates and ammonia being soluble in water are easily carried away by surface run-off or groundwater. They thus remain dissolved in lakes, rivers and oceans and can be taken up by aquatic plants and recycled through aquatic food webs.

[III] The Oxygen Cycle

Oxygen is found dissolved in surface waters and in the pore spaces of soils and sediments. Oxygen forms a large number of important substances. The oxygen containing

substances include water (H_2O), carbon monoxide (CO), carbon dioxide (CO_2), sulphur dioxide (SO_2), plant nutrients like nitrate (NO_3^-) and phosphates (PO_4^{3-}), organic substances such as sugars, starches and cellulose and virtually all rocks and minerals. The oxygen cycle is shown in figure (4).

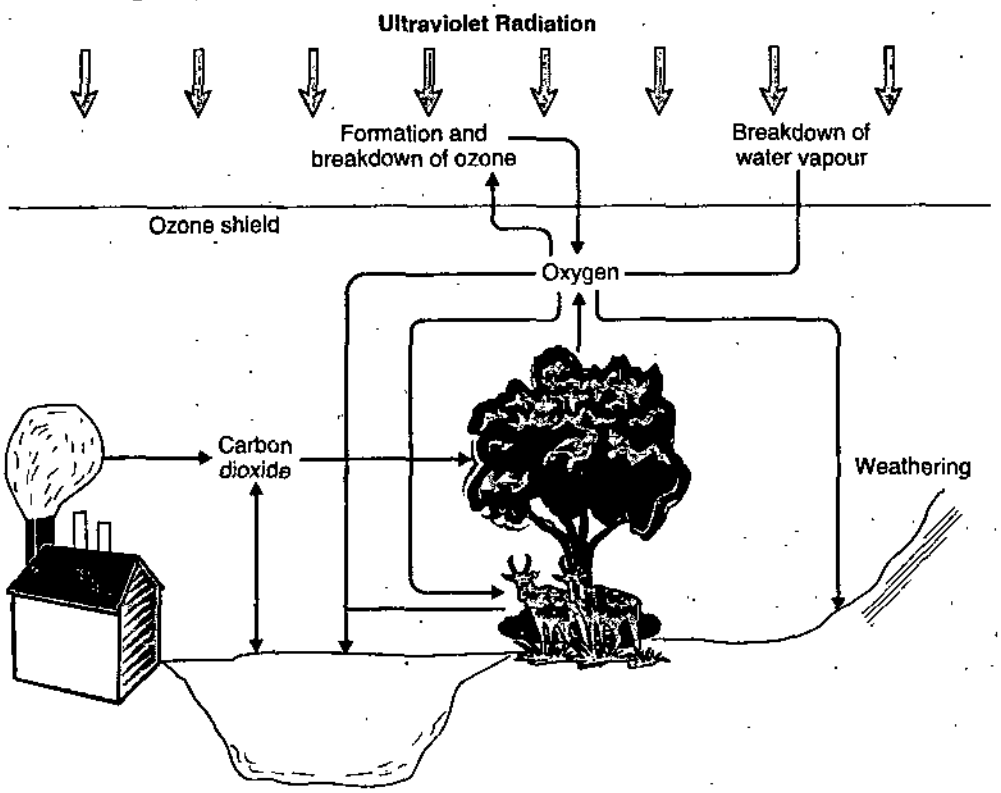


Fig. 4. The oxygen cycle.

One oxygen sub-cycle consists of inter-relationship of photosynthesis and respiration. Oxygen gas is combined with sugar through respiration and one of the products is carbon dioxide. On the other hand, in photosynthesis, carbon dioxide is combined with water vapours in presence of sunlight to form sugar and oxygen.

Exchanges of oxygen between the atmosphere and ocean forms another sub-cycle. The exchange of oxygen between the ocean and atmosphere is balanced, so that its contents remain the same in the atmosphere. Ocean currents and waves carry dissolved oxygen into deeper waters to sustain aquatic life at great depths.

As seen, oxygen enters the nitrogen cycle through atmospheric fixation, whereby oxygen gas is combined with nitrogen gas to form nitrate. Due to denitrification, nitrate is changed back into nitrogen gas, which escapes back to the atmosphere.

[IV] The Water Cycle

The total volume of water on earth has remained virtually constant over the past several million years. Water is taken up from the sea and land to form clouds, rain and snowfall. The clouds are then converted into rainfall and water thus falls on earth which is supplied to rivers and the rivers finally flow back to the sea. The pattern of water's movement is known as ***hydrologic cycle*** [Fig. (5)]. It can be aptly mentioned : ***"All the rivers run into the sea, yet sea is not full".***

[V] Types of Air Pollutants

Depending on the physical state of pollutants, the air pollutants are of two types :

(1) Gaseous pollutants : ***The pollutant which is mixed with air in the gaseous state and does not settle down is known as a gaseous pollutant.*** Vapours of the compounds where boiling point is below 200°C are also included in this category. These are organic and inorganic gases, *e.g.*, carbon monoxide (CO), carbon dioxide (CO_2), sulphur dioxide (SO_2),

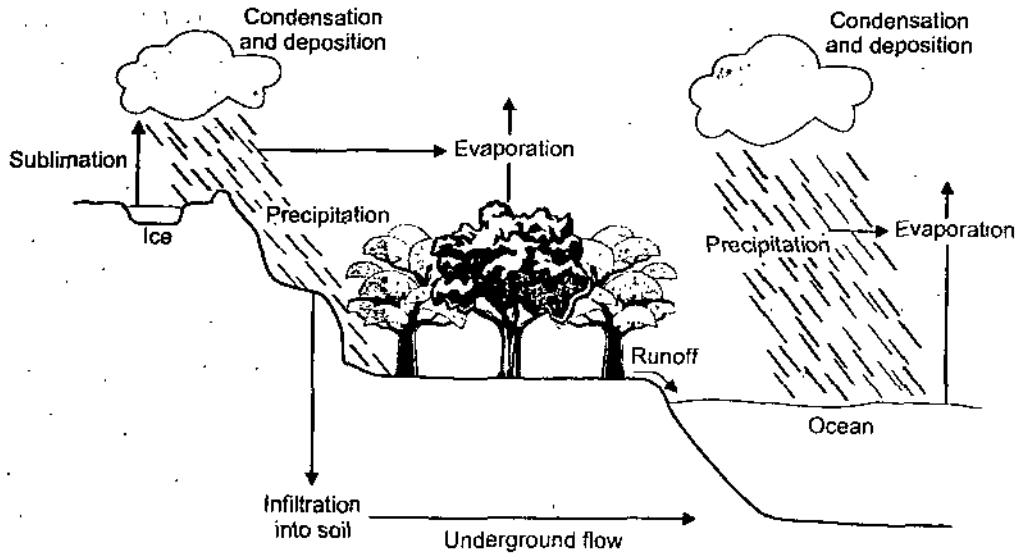


Fig. 5. The water cycle.

hydrogen fluoride (H_2F_2), chlorine (Cl_2), oxide of nitrogen, ozone (O_3), hydrocarbons, ammonia (NH_3), aldehydes, mercury vapours (Hg), benzopyrene etc.

(2) Particulate pollutants : ***Those pollutants which are mixed with air in the liquid or solid state and after sometime settle down at the surface of the earth are called particulate pollutants.*** These are of two types : (a) settleable and (b) suspended. The settleable dusts have a particle size larger than 10 μ. The smaller particles remain suspended in air for a long time. Heat produced in several industries and scattered by concrete, asphalt etc. during the day time helps in the dispersion of particulate particles. The particulate matter consists of the following substances :

(i) Carbon particles in the form of smoke. These include solid and liquid particles of size ranging from 0·05 to 1·0 micron (1 micron = 10^{-6} m) and obtained by the incomplete combustion of carbonaceous materials and by destructive distillation.

(ii) Lead and cadmium compounds.

(iii) Fumes coming out due to presence of various industries.

(iv) Hydrocarbon vapours emitted by automobile exhausts.

(v) Motor oil and cotton dust.

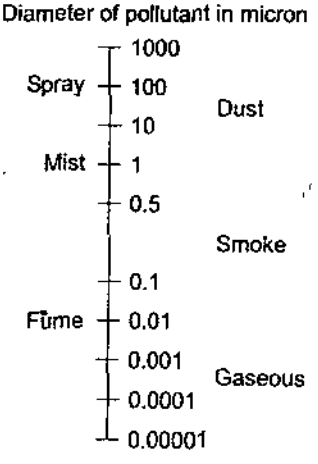
(vi) Non-volatile reaction products formed from motor oil in combustion with ozone.

(vii) *Dust.* Dust is formed by solid particles and their size range is from 1 micron to 100 microns. However, dust particle, with a size of 0.1 micron are also present in the atmosphere.

(viii) *Mist.* Condensation of vapour forms a liquid particle known as mist of size less than 10 microns, *e.g.*, SO_3 (gas), SO_3 (liquid).

(ix) *Spray.* Liquid particles obtained from the parent liquid by mechanical disintegration processes such as atomisation is known as spray.

(x) *Fume.* The fumes are generally formed from particles of the metals and metallic oxides. The size of these particles are less than 1 micron. Fumes are formed by the condensation of vapours by distillation, sublimation, calcination and other chemical reactions.



The chart [Fig. (6)] shows the approximate size ranges of both gaseous and particulate pollutants. In Delhi, the air pollution due to suspended particulate matter mainly smoke and atmospheric dust from factory chimneys, kitchen fires, automobile exhausts etc. is the highest in India.

[VI] Sources of Air Pollution

Though there are major sources of air pollution, yet the sources can be classified into the following categories :

(i) Combustion. *(ii) Manufacturing processes.*

(iii) Agricultural activities. *(iv) Solvent usage.*

(v) Nuclear energy.

(1) Combustion : This includes transportation, burning of fuel coal, wood etc. Some of them are described in brief as follows :

(a) Thermal power stations : These are the main sources of sulphur dioxide. Because of its high reactivity and short life in atmosphere, no appreciable build up is seen. All areas in the vicinity of thermal power stations suffer from sulphur dioxide fumes. If its proportion goes on increasing, it will create problems for animals, human beings, plant life, buildings etc.

(b) Aeroplanes : The fuel in aeroplanes when burnt gives off sulphur dioxide as pollutant in the upper parts of the atmosphere. This forms sulphurous and sulphuric acid which are poisonous and fall on the ground with rain and pollute the rivers, soil etc. Sulphuric acid destroys animals, plants and decreases the fertility of soil.

(c) Combustion of coal : Due to combustion of coal, we get carbon monoxide, oxides of nitrogen, sulphur dioxide, hydrocarbons, aldehydes as pollutants. The quantities of these depend on the composition of coal, method of firing, atmospheric conditions. The burning of coal also produces fly ash emissions and particulate emission in the form of benzopyrene.

(d) Automobile vehicles : Man is mainly responsible for producing air pollution due to exhaust gases from automobile vehicles, like cars, scooters etc. Due to combustion of petrol, diesel oil, these automobiles give off smoke containing a high percentage of carbon monoxide. When this gas enters our system, it reacts with haemoglobin of blood and obstructs the flow of oxygen in our tissues. It thus produces headaches.

(2) Manufacturing Processes : A number of chemical and industrial plants produce air pollutants, as mentioned below :

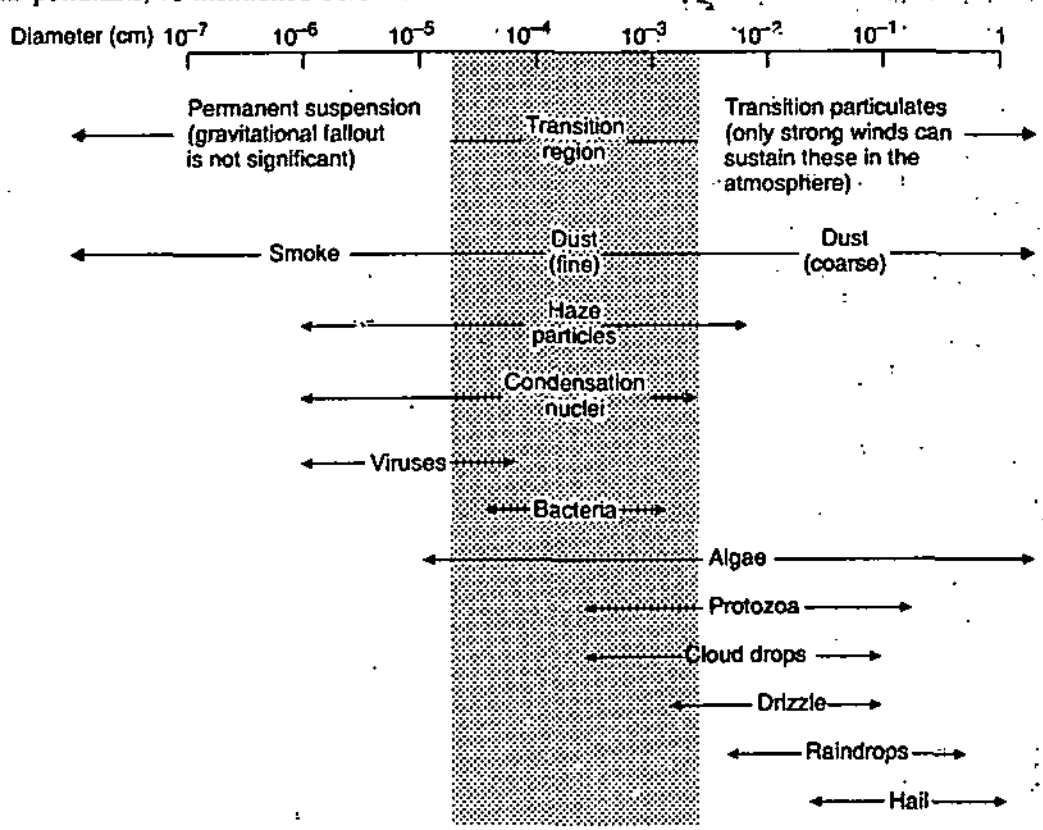


Fig. 7. Relative diameters and settling velocities of particles.

(a) Fertilizer complex : It releases oxides of nitrogen and dust particles. Dust particles are formed from processes such as drying, burning, grinding, calcining, mixing etc. In urea manufacturing industry, the urea dust from drilling tower is the air pollutant.

(b) Cement factories : The cement dust is a common air pollutant around cement factories. It is chemically a mixture of oxides of potassium, aluminium, calcium, sodium and silicon. This dust decreases the size and number of leaves in plants. The growth of plants is also retarded.

(c) Sulphuric acid industry : The industries producing sulphuric acid discharge large quantities of sulpher dioxide in air and pollute the atmosphere appreciably.

(d) Fluoride industry : Concerns manufacturing compounds of fluorides have serious effect on human beings, animals and plants. Due to fluoride dust, horses and poultry etc. develop fluorosis. Cattle and sheep are susceptible to fluorine poisoning. Hydrogen fluoride destroys the fruits and leaves of plants.

(e) Nitric acid plants : These plants release oxides of nitrogen as pollutants to the atmosphere. They form toxic substances in polluted urban areas. They also consume a good quantity of ozone of the atmosphere.

(f) Iron and steel industry : These industries emit sulpher dioxide, metal oxides, carbon monoxide and carbon dioxide as pollutants.

(g) Petrochemical refineries : An oil refinery emits emissions like particulate matter carbon monoxide, formaldehyde, ammonia, gasoline, kerosene, fuel oil, nitrogen dioxide etc.

(3) Agricultural Activities :

(a) Crop spraying : When crops are sprayed by pesticides, weedicides etc. a number of organic-phosphates, chlorinated hydrocarbons, lead, mercury are released as pollutants.

(b) Sewage and domestic refuse : Cooking smells, gases from sewage and domestic refuse, breeding industry and catering industry cause air pollution, giving off fly ash, aldehydes, hydrocarbons, carbon dioxide, carbon monoxide and other obnoxious gases etc.

(4) Solvent Usage : During the processes of painting of furnitures, cars, scooters and other implements, dyeing, printing, degreasing, drycleaning etc., a number of pollutants like hydrocarbons and organic vapours are given off to the atmosphere.

(5) Nuclear Energy : Due to radiations emitted by radioactive explosions, nuclear reactors, the air is polluted due to uranium and beryllium dust, radioactive fall out in the form of strontium-90, caesium-137, carbon-14 etc. A number of radioisotopes are used in research, in treating diseases like cancer, thyroid etc.

The main pollutants and their sources of generation are given in the following table.

Table 4.

Pollutant	Major sources
1. Smoke, dust etc.	Cement and gas works, iron and steel works.
2. Carbon dioxide and carbon monoxide	Combustion of fossil fuels.
3. Sulphur dioxide	Oil refineries, iron and steel works, electricity generation etc.
4. Oxides of nitrogen	Nitric acid industry, electricity generation, fertilizer plant, iron and steel industry.
5. Ammonia	Fertilizer and ammonia industries.
6. Sulphur trioxide	Brick works, H_2SO_4 industry.
7. Chlorinated hydrocarbons	Dry cleaning work.
8. Mercaptans	Oil refineries, coke ovens.
9. Freon	Refrigeration works.
10. Cr, Ni, CO etc.	Dyeing and printing industries.
11. Sulphur and sulphides	Generating stations, rubber vulcanising, coke ovens, metal smelting etc.

[VII] Effects of Air Pollution

In industrialised and main cities, the number of air pollutants are quite appreciable. Some pollutants get oxidised and require oxygen. As a result of this, the oxygen content in the atmosphere decreases and becomes unfit for human beings, plants, animals etc. We will now study the effect of air pollution on plants, animals, human beings, building materials etc.

(1) Particulate Matter : The important effects of particulate matter are :

(a) Particulate matter suspended in air scatters and also absorbs light, whereby the visibility is much reduced. It is hazardous to vehicle drivers.

(b) Dust and smoke particles act as nuclei for condensation of water vapours and produce ***smog***. The smog particles attract molecules of H_2S, NO_2, SO_2 etc. Thus, smog not only reduces visibility, but is harmful to mankind and plant life. Dust and smoke particles cause irritation of the respiratory tract and produce asthama, bronchitis and lung diseases.

(c) It is found that cotton dust produced in fine mills, coarse and ginning mills produce ***pneumoconiosis*** or ***lung fibrisis*** known as ***byssinosis***. Other diseases caused are eye irritation and cancer. Asbestos dust produces cancer of lung, stomach and intestines.

(d) Smoke and dust particles which setle over the vegetation not only clog stomata, but also form a thin layer on the leaves to reduce light absorption and so photosynthesis.

(2) Carbon Dioxide : Carbon dioxide quantity in atmosphere is slowly rising due to large scale burning of fossils and other organic fuels without a corresponding increase in plant population. Carbon dioxide content in the atmosphere has increased by 15 percent during the last century and it is still rising. The carbon dioxide addition in atmophere results in rise in temperature and according to scientists when all reserved fossil fuels are burnt in another 3–4 centuries, the air temperature will rise by a few degrees. This will cause melting of snow on poles and mountain tops that would threaten a rise of 18–20 metres in the sea level. Thus, a large number of low lying areas will be submerged.

(3) Carbon Monoxide : It is the asphyxiating agent most common in our environment. It combines with the haemoglobin in blood to form carboxy haemoglobin and thus reduces the haemoglobin available to carry oxygen to the body. It accounts for more than 50 percent of the total weight of pollutants added to the atmosphere. It is formed by the incomplete combustion of carbon fuels in various industries, motor vehicles, hearths etc. Plants alone emit 108 tons of carbon monoxide out of a total production of $2 \cdot 5 \times 10^9$ tons from various sources.

This gas when inhaled combines with the haemoglobin of blood about 210 times faster than oxygen does and results in oxygen deficiency. At 100 ppm concentration, carbon monoxide produces giddiness and headache within less than an hour. Persons already suffering from diseases associated with the decrease of oxygen carrying capacity of the blood such as anaemia may be affected quickly and carbon monoxide may cause even injury to vital organs in such persons. However, this gas is not a cumulative poison and is excreted or absorbed according to the partial pressure of it in the ambient air and the percentage saturation of haemoglobin. At higher concentrations, it proves fatal. It also affects oxygenation of tissues. However, it has no adverse effects on vegetation.

(4) Sulphur Dioxide : It is the next most common pollutant which is formed by burning of sulphur containing coal and petroleum, thermal plants, homes and automobiles. It is quite harmful and causes diseases of eyes, throat and lungs. It causes skin diseases. In air, sulphur dioxide combines with fog to form ***smog.*** Sulphur dioxide combines with oxygen to form sulphur trioxide which combines with water to form H_2SO_3 (sulphurous acid) and H_2SO_4 (sulphuric acid). Thus, oxygen is called ***primary pollutant,*** while the latter are known as ***secondary pollutants.***

Sulphur dioxide also acts as an ***allergenic agent.*** As it injures the mucosa, the micro-organisms close the injured mucosa as a ***nidus*** (a place in which spores or seeds

develop, a place for laying eggs for insects and small organisms) for their reproduction and this leads to severe infections and allergic response.

Sulphur dioxide causes ***chlorosis*** (yellowing of leaves due to chlorophyll loss) and ***necrosis*** of vegetation in as low concentration as 003 ppm. The leaves often assume water-soaked appearance. Monocotyledons are more sensitive and so cereal crops are damaged in areas around smelters and industrial belts. It causes bleaching of leaf pigment. Coniferous forests, mango and apple orchards are also destroyed around brick kilns and other places where coal is burnt in large quantities.

Sulphur dioxide results in discolouration and corrosion of buildings and marble structures, fabrics, paper, leather. The Taj Mahal at Agra is likely to be affected by gases that are discharged from the nearby Mathura Oil Refinery. However, it has been realised and anti-pollution measures have been taken. It also corrodes metals like zinc and iron. So, it impairs electrical and other metallic equipments.

(5) Chlorine : This is found in volcanic eruptions. It is also given out in the manufacture or use of chlorinated chemicals, *e.g.*, bleaching, germicides, deodorants etc. It causes eye and respiratory diseases. Chlorine rising up in the stratosphere poses danger to protective ozone layer placed at a height of nearly 20–25 km.

(6) Photochemical Oxidants : Some substances combine with other substances in the atmosphere to produce poisonous products. The tolerance limit of ozone is 03 ppm per hour. When ozone combines with unburnt hydrocarbons of automobile exhausts, sunlight and aldehydes, compounds known as ***photochemical oxidants*** are produced. These cause irritation of eyes, nose and throat. In plants, they affect the flecks on upper surface, premature ageing and decrease the growth. Ozone hardens rubber and discolours textiles.

Another pollutant ***peroxyacetyl nitrate*** (PAN) is produced due to the combination of aldehydes, oxides of nitrogen, sunlight and ozone. It causes irritation of skin, eyes, nose and throat. It also produces cancer in men. In plants, it checks their growth and suppresses the production. It also affects the bronzing of lower leaf surface, especially the young leaves.

(7) Oxides of Nitrogen : These are produced mostly by combustion of fuel, solar flares, high energy radiations. The important effects of oxides of nitrogen (N_2O, NO, NO_2, N_2O_4, N_2O_5) are as follows :

(a) They give rise to photochemical smog.

(b) They act on unsaturated hydrocarbons to form PAN.

(c) In moisture, they have a corrosive action on metals.

(d) They cause fading and spoiling of several types of textiles.

(e) They cause irritation in eyes and respiratory problems. They produce cancer and affect lungs, liver and kidneys.

(f) They produce lesions, necrosis, defoliation and death of many plants.

(g) They destory the protective ozone layer in the stratosphere.

(8) Hydrocarbons : These are emitted to the atmosphere as part of natural gas, incomplete combustion of organic fuels and decay of organic debris under water logged parts. The hydrocarbons are chiefly methane and ethylene. Methane retards the growth of plants and production of fruits. It also affects the skin, throat and lungs. Ethylene is a gaseous harmone of plants which helps in abscission, fruit ripening etc. Many hydrocarbons have carcinogenic properties. Ethylene produces chlorosis of floral buds and stops growth. In mankind, it affects the mucous membrane, causes irritation in eyes and produces cancer in lungs. On December 2, 1984, the well known ***Bhopal gas tragedy*** is one of the examples where methyl isocyanate (MIC) gas affected the lives of hundreds of thousands of human beings.

(9) Other Air Pollutants :

(a) Hydrogen sulphide produced by many chemical industries, refineries has smell of rotten eggs and causes irritation of eyes, throat and nausea.

(b) Hydrogen cyanide given out by chemical and metal plating industries, blast furnaces attacks nerve cells, produces giddiness, impair vision and dry throat etc.

(c) Ammonia escapes from dyes, explosive, fertilizer industries and produce irritation and inflammation of upper respiratory tract.

(d) Ozone has been reported to be a strong irritant and it is supposed to reach the lungs much faster than the oxides of sulphur. Even low concentration of ozone causes pulmonary oedema and haemorrhage.

(10) Radioactivity : Man is exposed to ionised radiation from natural radioactive substances in the body which contains radio-potassium. We inhale radon which is present in air. It is exposed to cosmic rays coming from the outer space. Low doses of radioactive radiations can produce changes in human body cells leading to the induction of cancer after 15–20 years. They also cause genetic effects in the off- spring of people exposed to radiations. Radioactive contamination of oceans have increased due to nuclear weapons testing and operation of nuclear submarines.

The use of satellites have increased radioactive pollution in air. They number 700 at present and are used for several purposes and if they destroy each other they will produce magnetic storms, which will change even the climate of the world. The solar winds so caused will carry the ultraviolet rays, causing cancer of skin in human beings.

(11) Noxious or Offensive Gases : Those gases which cause irritation, cancer in human beings, animals and blindness are called noxious gases. They also destroy the building materials and plants. Some of the gases are arsine, NH_3, Cl_2, Br_2 and their compounds, chlorides of sulphur, fumes from cement, rubber, steel works etc. These gases cause headache, vomiting, blindness along with skin, heart, liver and kidney ailments. They affect necrosis, intervenal areas and skeletonise the leaves.

[VII] Remedial Measures to Check Air Pollution

There are a number of devices which have been developed to check particulate materials and harmful gases from being discharged into the atmosphere. Air pollution cannot be completely checked but its effects can be minimised by adopting the following measures :

(1) If the gaseous waste is passed through a porous chamber, the particles are held up. The gases could then be passed through a water tower before discharging in the atmosphere, so that most of the water soluble pollutants are absorbed.

(2) Too much use of fossil fuels like coal and petroleum should be avoided as far as possible and instead hydroelectric and solar power should be produced and used more and more.

(3) Complete combustion engines and anti-smog devices be fitted in automobiles. Clean fuels like alcohol, hydrogen and electricity be used in place of diesel and petrol.

(4) Factory area should be separate and quite some distant away from residential areas.

(5) Emission of smoke and smoking be stopped or reduced in congested and closed areas.

(6) Proper pollution control equipment be installed at the design stage.

(7) Industries and professions releasing particulate matter be fitted with safety devices to protect the workers from coming in contact with it.

(8) Plants should be grown to fix carbon monoxide, *e.g., daucos carota, coleus blumei, ficus variegata* etc.

(9) Plants should be grown which are capable of metabolising nitrogen oxides and other gaseous pollutants, *e.g., pinus, vitis, pyrus, crataegus, rhamnus, juniperus* etc.

(10) The high level radioactive wastes should be kept stored either in very large closed drums or large underground air tight pucca tanks. The intermediate radioactive wastes can be disposed off into the environment after diluting it with some inert substance.

Proper legislation and implementation be made by the government. Anti-pollution boards be set up by the central and state governments to analyse the samples taken from time to time. In case, any violation of law is observed, strict action or heavy penalty or both be imposed.

• 3.4. SOIL POLLUTION

The medium in which plants grow is soil. From the soil, the plants derive water and other nutrients. It also acts as a reservoir for all water plants, submerged or rooted plants. Soil is defined as the, ***"surface of the earth's crust which is mixed with organic matter and in which plants grow."***

[I] Composition of Soil

A soil contains four parts, *viz.*, mineral matter, organic matter, water or solution and air.

(1) Mineral matter : This part of the soil occurs in the form of particles. The particles are irregular in size and shape, so that they cannot be packed tightly. They enclose numerous spaces for the circulation of water and air. The weight of mineral matter provides for achorage of the plants.

Depending upon the size, the mineral particles have been termed as :

(i) *Coarse gravel* (above 5 mm), (ii) *Fine gravel* (2–5 mm),
(iii) *Coarse sand* (0.2–2.0 mm), (iv) *Fine sand* (0.02–0.2 mm),
(v) *Silt* (0.02–0.02 mm) and (vi) *Clay* (less than 0002 mm).

Sand and gravel give physical support to the plants, while silt and clay determine the water holding capacity and nutrient availability of the soil. Sand, silt and clay form most of the mineral matter of the soil.

A soil in which the sand, silt and clay particles are present in more or less equal amounts is called ***loam*** and is most suitable for plants growth.

(2) Organic matter or humus : It is derived from fallen leaves, twigs, roots etc., dead bodies of organisms and their excreta. The organic matter undergoes partial decomposition to form a dark amorphous substance called ***humus,*** a process known as ***humification.*** Organic matter or humus has several benefits, *viz.*,

(i) The various mineral nutrients removed by the plants are returned to soil through litter (plant debris fallen on the ground).
(ii) It keeps some minerals like sulphur, phosphorus in the bound form for a long period.
(iii) Organic acids and their salts have a buffer action against changes in pH.
(iv) Litter and humus lying on the upper surface of the soil protect its compaction and runoff. They increase the rate of water absorption.
(v) It reduces the drastic temperature fluctuations.
(vi) It is the source of food to many soil organisms.
(vii) It decreases the growth of some pathogenic organisms.
(viii) It contains some growth promoting chemicals like humic acid etc.

(3) Soil water : Soil water is most important in the distribution of plants, as it is not only required for meeting the metabolic and transpirational needs of the plants, but it is also the medium in which soil salts get dissolved. The activities of soil flora and fauna and the process of humification depend upon the availability of water.

Soil water is derived from rain. All the rain water falling on the soil is not retained. Some water is drained away from the soil surface along the slope. It is called ***runaway water.*** Some water is drained downwardly under the influence of gravity. It is called ***gravitational water.*** Water which is kept absorbed or inbibed over the surface and inside the interstices of soil colloids is called ***hygroscopic*** or ***imbibitional water.*** Some water occurs in the soil atmosphere and is called ***water vapour.*** Some water is present inside the micropores, at the angles of macropores and as thin films around the soil articles. This is called ***capillary water.***

The total water present in the soil is called ***holard***. The amount of water that plants can absorb is called ***chresard*** and which it cannot absorb is called ***echard.***

(4) Soil air : Soil has a porous structure and about 35–60 percent of it has porous spaces. These spaces are filled by moisture and partly by air. The soil aeration is important for the proper functioning of the roots of the soil. It increases the fertility of soil.

[II] Sources of Soil Pollution in India

Soil pollution usually results from the disposal of solid and semi-solid wastes from agricultural practices and from insanitary habits. Fall out from atmospheric pollution also contributes to soil pollution.

In India, the soil is polluted by city's solid refuse and solid or liquid effluents from industires like oil refineries, pulp and paper, fertilizers, iron and steel, plastic, rubber etc. These are either buried or dumped in the soil. Most of the industries emit unburnt brownish-black substance known as flyash. It is one of the main soil pollutant. It can be degraded by natural biological processes of bacterial decay and converted into valuable compost manure. The factory waste contains several substances which are poisonous to biological community. These are dumped into surrounding soil or discharged into streams through drains. All along its flow, they also pollute the adjoining land.

The radioactive pollution resulting from the fission of highly radioactive substances like uranium and atomic explosion tests in USA, France, Russia and China result in tremendous energy and also harmful and non-essential by-products like caesium-137, iodine-131 and strontium-90, ruthenium-106, barium-140 etc. These and other radioactive products enter the air as fall-out. In regions of heavy rainfall, they settle down with rain drops on land and enter the soil. It is because rains make strontium-90 and caesium-137 to be deposited on the soil and it is held firmly to the soil by electrostatic forces. Heavy rains and soil erosion carry away the deposited strontium-90 and caesium-137 with the silt and clay. A recent report shows that certain plants such as *lichen* can accumulate caesium-137 and a concentration of radionuclides in animals occur when these plants are fed. All the radionuclides deposited on the soil emit gamma radiations. It produces, genetic defects, cancer etc.

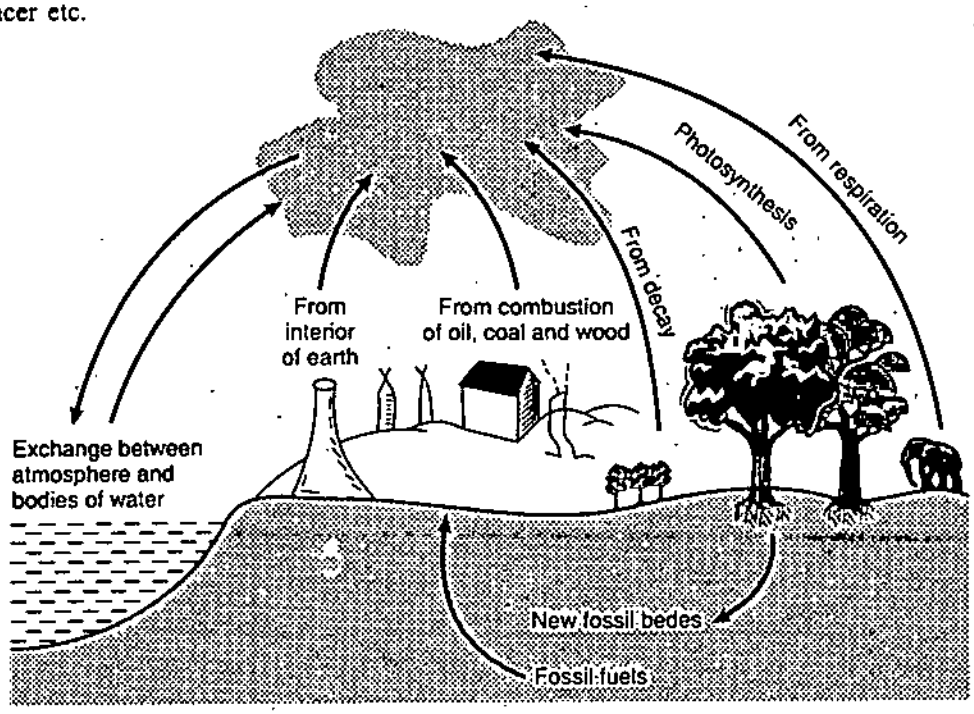


Fig. 8. Soil pollution.

Cosmic radiations and explosion of hydrogen weapons which induce neutron-proton process by which nitrogen produces carbon-14 is also responsible for carbon metabolism of plants.

Another source of soil pollution is the use of chemical fertilizers, pesticides, fungicides, weedicides, insecticides which are widely used for obtaining better and larger yields in agriculture. Complex organic compounds like DDT, dieldrin, aldrin, heptachlor, benzene hexachloride (BHC) are used as sprays for plant protection. Their decomposition is slow. Both on land or soil, they enter the food chains beginning with plants and finally reach the plants. These substances flow with water and destroy the ecosystem.

Metallic pollutants like sodium, copper, chromium, cadmium and mercury discharged from various industries affect the quantity and quality of agricultural crops and soil properties are also adversely affected.

[III] Types of Soil Pollution

Soil pollution can be broadly classified into the following three categories :
(i) Biological pollution, (ii) Chemical pollution, (iii) Radioactive pollution.

(1) Biological pollution : It is caused by the following pollutants :

(a) Dog and cat hookworm larvae (b) Eggs and larva of parasitic worms
(c) Fungi (d) Spores
(e) Tetanus bacillus (f) Toxin
(g) Enteric bacteria etc.

They are passed into the soil by waste of animals and humans, flies, agricultural crops. Some of the diseases caused are cholera, typhoid, mycosis, tetanus etc. Earthworms, hookworms, roundworms are also produced in the human beings as a result of which appetite and health are affected.

(2) Chemical pollution : It is caused by the use of chemical fertilizers, pesticides, fungicides etc. like D.D.T., aldrin, BHC etc. When these are added to the soil to increase the productivity of crops, these poisonous substances enter the underground vegetables like potato, carrot, radish, turnip etc. The compound of lead is present in soil and atmosphere, but it affects the humans only when present in larger quantities.

(3) Radioactive pollution : Radioactive emissions are given out due to nuclear reactors, radioactive laboratories etc. These emissions are harmful. Two radioactive isotopes strontium-90, caesium-137 have very long half lives of 27·5 and 3145 years, respectively. Both these isotopes remain in the upper part of the soil. Caesium-137 is absorbed by some plants like mushrooms, lichens etc., so it is not very harmful. However, it accumulates in the body muscles. Strontium-90 and iodine-127 are absorbed by a large number of plants, so it is more harmful and are accumulated in bones and thyroid. They cause cancer, malformation of body at birth, organ abnormalities in the animals etc.

[IV] Control of Soil Pollution

(1) It should be emphasized and plans be made so that the industrial effluents reach the air, water and soil in their minimum harmful effects. For example, the solid wastes be collected at a proper place and then dumped inside the soil.
(2) The wastes should be burnt and the heat produced be utilized by different works.
(3) Composting of the organic wastes like cow-dung, for preparation of manures and bio-gas.
(4) Ban should be imposed on nuclear explosions and no radioactive wastes should be allowed to reach the atmosphere.

• 3.5. MARINE POLLUTION

When waste substances are discharged into the sea they result in harm to living resources, hazards to human health, hindrance to fishery and deterioration of quality for use of sea water. This type of pollution is called ***marine pollution.***

[I] Sources and Effects of Pollutants in Marine Water

Marine pollution is a major threat to any organism living in or depending on the ocean. Human impact on coastal and open ocean habitats comes in many forms : nutrient loading

from agricultural runoff and sewage discharges, toxic chemical inputs from industry and agriculture, petroleum spills and inert solid wastes. Nutrient loading is perhaps the most well studied form of pollution and its biological consequences have been observed and documented. Algal blooms, including red tides have been attributed to elevated nutrient levels in coastal systems. These blooms, through their respiration and decomposition can deplete the levels of dissolved oxygen in the waters to almost zero, killing zooplankton, fish and shellfish. These nutrients often come from runoff of agricultural fertilizers, the use of which has increased seven fold since 1950.

Another source of nutrients is the discharge of sewage. The United States and England are the only countries that dump sludge into the ocean. Throughout the world, however, raw sewage is released into rivers and coastal habitats by many countries, leading to algal blooms and increased biochemical oxygen demand (BOD), the rate at which oxygen disappears from a sample of water, increases dramatically with loading of organic material such as sewage and results in the lowering of dissolved oxygen levels. The wastes of domesticated animals may also have a major impact in some systems. When animal waste produced by large herds or feedlots is discharged into rivers or coastal waters, they may have substantial effects.

Toxic substances are introduced into the marine environment from various sources, some of which may be hundreds of kilometres away. Heavy metals, pesticides and acid rain threaten not only coastal and estuarine systems, but also life in the open ocean. Heavy metals occur in many forms, some of which are soluble in sea water. These soluble compounds may not be the forms in which they were originally released into the environment, often making their sources difficult to determine. Many heavy metals are released in industrial effluents, especially from chemical plants, smelters and mining runoff. These compounds may affect humans directly through contact or indirectly from the consumption of fish and shellfish, where metals often accumulate in tissues. Other metals, such as zinc, cadmium, copper and silver are commonly discharged into marine systems by industry. Not only are these metals toxic by themselves, but synergistic effects compound their toxicity.

CASE STUDY

Between the late 1930s and the mid 1950s, a Japanese chemical company manufacturing acetaldehyde (CH_3CHO) discharged mercury into Minamata Bay, where if formed a soluble compound that accumulated in fish. It was not until 50 people died of *Minimata disease* and hundreds were left with debilitating nervous disorders from eating poisoned fish that environmental studies were initiated. Finally, in 1969 the plant was closed.

Toxic organic compounds, especially pesticides and a family of chemicals known as PCBs, have been shown to have serious effects on marine systems. Runoff has introduced considerable amounts of PCBs, DDT and many other synthetic organic compounds into coastal areas. These compounds may persist for many years. Biologists claim that these compounds inhibited the dolphins immune systems, making them vulnerable to infections.

Another source of marine pollution is **petroleum products.** While large oil spills can devastate a local area, equally important is the discharge of crude oil while cleaning bilges and emptying tanks at sea. Since tanker ports and refineries are, by necessity, located on the coast, these sensitive areas receive considerable damage from the spills. The damage to marine life is staggering, seabirds are killed by the hundred of thousands annually, their oil-matted plumage making flight impossible and exposing them to *hypothermia* (low body temperature). Oil soaked fur of marine mammals loses its water repellency, also leading to death by hypothermia. Ingestion of oil by fishes, birds and mammals also may result in death. Oil slick decreases the light intensity upto 90 percent. Such diffused light may hamper the photosynthesis in aquatic life.

Hundreds of tons of inert solid wastes are dumped into the oceans from ships annually. Of these, **plastics** and **polystyrene** (styrofoam) are deadly to marine life. Often floating for hundreds of miles and lasting for many years, plastics are frequently mistaken for food by fishes, turtles and mammals and proceed to either interfere with subsequent feeding or strangle the consumer. It has been estimated that plastics and discarded fishing gear, such as monofilament line and discarded nets, kill one million seabirds and 1,50,000 marine mammals annually.

[II] Control Measures and Laws for Marine Pollution

Beginning with different pollution acts, there have been efforts to remedy the polluted oceans. Pollution of the world's oceans had become so pervasive that an international convention was convened in 1973 to establish laws governing the discharge of all wastes into the ocean. The **International Convention for the Prevention of Pollution from Ships** (1978), commonly known as MARPOL, and subsequent annexes to the convention, covers all garbage discharged by ships at sea beyond three miles from shore. MARPOL agreement should significantly reduce the amount of solid wastes polluting the world's oceans.

Methods have been devised to deal with oil spills on the seawater. This can be achieved by physical or chemical methods. *Physical methods* include :

(i) Skimming off the oil surface with a suction device
(ii) Coagulating the oil by using chemicals.
(iii) Spreading a high density powder over the oil spill, so that oil can be sunk to the bottom.
(iv) Treating the oil spill by chalk with stearate and 10 percent sand in water.

The *chemical methods* include dispersion, evaporation, emulsificatin, using chemical additives, using floating booms, using micro-organism in oil clean up.

• 3.6. NOISE POLLUTION

[I] Introduction

The sound that we hear goes into our brain by way of our ears. Normally, the sound which is pleasing to the ears may be termed as **music.** The same music may be called **noise,** if quiet is desired. So, we can define **noise as an unwanted sound.**

Noise is produced due to congestion in urban areas, vehicles, railways, helicopters, jets, rockets, radio, T.V., call bells, alarm clocks, telephone rings, machines or factories, coolers, loudspeakers, mixer grinders, public broadcasting by religious institutions etc. The waves left by supersonic jets give rise to sonic booms or sudden rattling of doors and windows.

There are two main characteristics of sound, *viz.*, (a) Pitch and frequency of sound waves and, (b) Loudness or intensity of sound waves.

The pitch of a sound depends on its frequency. A sound of higher frequency has a higher pitch. The pitch of woman's voice is higher than that of a man. The human ear can detect sounds over a wide range of intensities and frequencies. Normally, the human ear is sensitive to sounds having frequencies varying from 17 to 20,000 Hz (1 Hz = 1 cycle per second). Those sound waves which have frequency lower than 17 Hz are termed **infrasonic** and waves which have frequency higher than 20,000 Hz are termed **ultrasonic.**

The other characteristic of sound, *i.e.*, loudness means the intensity of sound wave. The loudness depends on sound frequency as well as sound intensity or pressure. The relative loudness of a sound is measured in terms of **decibels** (deci = 10 and *bel* = named after the scientist Graham Bell). *Decibel or dB is the unit of power level of a sound wave.* The threshold of hearing is taken as 0 dB. Ten times this power level is 10 dB. The fundamental unit is *bel,* but decibel is exclusively used (1 dB = 0·1 bel). A sound level meter which has a microphone amplifier and weighing networks and an indicating meter measures intensity of sound in dB.

Some of the metropolitan cities in India, *e.g.*, Delhi, Mumbai, Chennai and Calcutta have noise level far in excess of internationally accepted limits. The limit is 45 dB, whereas the major cities have a noise level of 90 dB and never falls below 60 dB. The following table shows the average noise levels from different sources.

Whisper	20–25 dB
Normal voice	60–65 dB
Threshold of discomfort	120 dB
Threshold of pain	140 dB
Motor cars	80–90 dB
Grinders	90–100 dB
Boeing 707	160 dB
Rocket booster	200 dB

[II] Effects of Noise Pollution

Noise affects man adversely in several ways, *i.e.*, having ability to communicate, behaviour etc. Unlike smoke pollution, noise pollution is not visible. Normally, the people remain unaware of noise pollution, till it is too late to overcome it. The human ear has a safety mechanism to protect itself from the damage, provided the exposure to noise is not continuous or for a long period. Excessive noise causes loss of hearing and disturbs mental peace. To determine the level of noise which may be termed as excessive noise, we consider the time of exposure, as given in table 5.

Table 5.

Duration per day (hours)	Sound level (dB)	Duration per day (hours)	Sound level (dB)
0.25 or less	115	3.0	97
0.5	110	4.0	95
1.0	105	6.0	92
1.5	102	8.0	90
2.0	100		

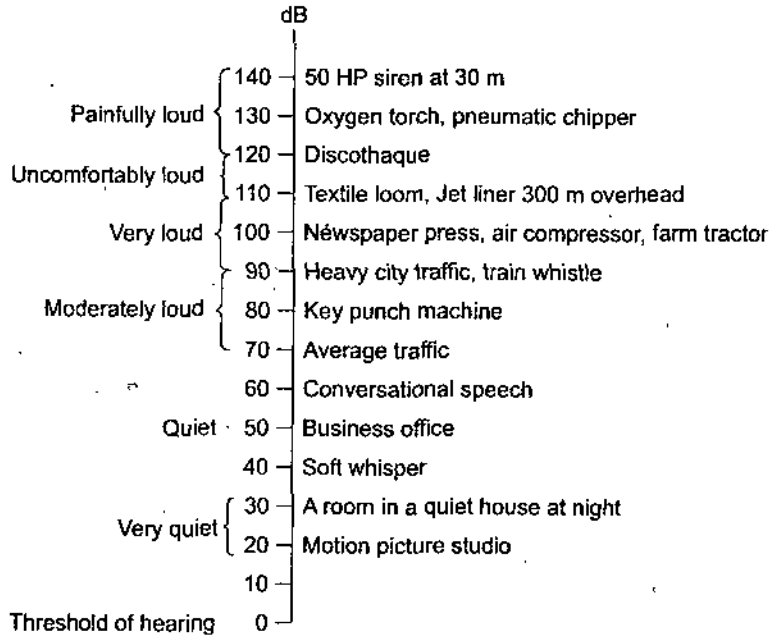


Fig. 9.

It means that if one is exposed to a sound level in excess of 90 dB for 8 hours per day and that too daily, it will cause permanent loss of hearing. Also, one should not be exposed to a noise level of 115 dB even for a short period.

Other effects of noise pollution are as follows :

(a) Noise pollution disturbs rest and sleep. The disturbance induces the development of annoyance and short temper.

(b) Constant noise may cause our blood vessels to contract, our skin to become pale.

(c) Noise pollution brings about dilation of pupil, tensing of muscles, decrease in gastric secretion and increase in diastolic blood pressure.

(d) Noise causes the secretion of adrenalin into blood stream which gives a feeling of fatigue and neuro-muscular tension.

(e) Small babies may develop a fear psychosis due to sudden and sharp noise.

(f) The noise produced by jet engines causes gastric ulcers and thymus gland atrophy.

[III] Control of Noise Pollution

(1) Silence zones be enforced around all institutions dealing with tender human factors and balanced behaviour, *e.g.*, hospitals, educational institutions etc.

(2) There should be restriction on unnecessary use of horns in motor vehicles.

(3) There should be sound absorbers in auditorium etc.

(4) In many industrial areas, noise level is quite high and it is not possible to bring it down. So, under these conditions, the people working and residing there should use certain personal protective equipment like ear plugs, ear muffs, semi-inserts, and helmets. The ear plugs fit into the ear canal. The ear muffs fit over the external ear, under which ear plugs may be worn. Semi-inserts close the entrance to ear canal, without being inserted into it and are supported by a head band. The helmets fit over the entire head under which the ear plugs and ear muffs may be worn, but these are generally not used.

However, the best way to guard against the ill effects of noise pollution is to prevent exposure to high noise levels, as there is no therapy, or surgery or medicine for hearing loss due to noise exposure.

• 3.7. THERMAL POLLUTION

[I] Introduction

The term **'thermal pollution'** has been used to identify the detrimental effects of heated discharges. However, the term, thermal pollution is not a good expression because heat itself is not a pollutant and this term does not refer to the impairment of purity by the addition of foreign matter as with water and air pollution. It shows the impairment of the quality of environmental air or water by raising (or lowering sometimes) its temperature.

Heat is produced in a number of common processes. The decay of organic matter in landfills releases heat to the atmosphere. Therefore, in many cases, heat added to the environment begins to cause problems for plants, humans or other animals. This effect is then known as **thermal pollution.**

[II] Sources of Thermal Pollution

The combustion of fossil fuels always produces heat, sometimes as a primary, desired product, and sometimes as a secondary, less desired product. For example, families burn coal, oil, natural gas or some other fuel to heat their homes. In such cases, the production of heat is the object of burning a fuel. Heat is also produced when fossil fuels are burned to produce electricity. In this case, heat is a by-product, not the main reason that fuels are burned.

One example of thermal pollution is the development of urban heat islands. An urban heat island consists of a dome of warm air over an urban area caused by the release of heat in the region. Since more human activity occurs in an urban area than in the surrounding rural areas, the atmosphere over the urban area becomes warmer than it is over the rural areas.

The electric power generating plants or factories generally heat lakes, river, streams and *other bodies of water. For example, a one megawatt nuclear power plant may* require five milion m^3 of cooling water each day. The water used in such a plant has its temperature increased by nearly 17°C during the cooling process. For this reason, such plants are usually built very close to an abundant water supply such as a lake, a large river or an ocean.

During its operation, the plant takes in cool water from its source, uses it to cool its operations and then returns the water to its original source. The water is usually recycled through large cooling towers before being returned to the source, but its temperature is still likely to be significantly higher than it was originally. In many cases, an increase of only a degree or two may be *'significantly higher'* for organisms living in water.

Another contributor to thermal pollution is municipal sewage. Domestic sewage is usually discharged into canals, rivers or streams with or without any treatment. The sewage will normally have a higher temperature than the receiving water. When sewage is discharged

into water, not only the river temperature rises to a measurable extent but there are some other effects. The organic matter present in the sewage and other oxidisable matter utilise the dissolved oxygen present in the surface water for oxidation. When the temperature of the receiving water is raised, the dissolved oxygen content decreases and the demand for oxygen increases. Therefore, anaerobic conditions will set up resulting in the release of foul gases. The same is the case with heated industrial effluents that contain organic matter.

[III] Effects of Thermal Pollution

The processes of life involve several chemical reactions and the rate of these reactions vary according to the changes in temperature. Apart from biochemical reactions, temperature is considered to be of vital importance to physiology and controlling reproductive cycles, respiration rates and digestion rates. The effects of thermal pollution are mainly on aquatic animals, particularly fish. Surface waters are the habitat for a wider variety of flora and fauna. The existence of these species depend only on the aquatic environment. The temperature of water is considered to be the major feature of the environment, since it may affect the concentration of dissolved oxygen, pH, the rate of biochemical reactions and the physical activity of aquatic animals.

Heating the water in a lake or river can have both beneficial and harmful effects. Every species of plant and animal has a certain range that is best for its survival. Raising the temperature of water may cause the death of some organisms, but may improve the environment of other species. Pike, perch, wall eye and small mouth bass, for example, survive best in water with a temperature of 29°C, while catfish, gar, shad and other types of bass prefer water that is about –12°C warmer. Spawning and egg development are also very sensitive to water temperature. Lake trout, walleye, Atlantic salmon and northern pike require relatively low temperatures.

Of course, large increases in temperature can have disastrous effects on an aquatic environment. Few organisms could survive an accident in which large amounts of very warm water were suddenly dumped into a lake or river. This effect is observed when a power plant first begins operation, when it shuts down for repairs and when it restarts once more. In each case, a sudden change in temperature leads to the death of many individuals and lead to a change in the make up of an aquatic community. Sudden temperature changes of this kind produce an effect known as ***'thermal shock'***. To avoid the effects of this thermal shock, power plants often close down or re-start slowly, reducing or increasing temperature in a waterway, gradually rather than all at once.

One inevitable result of thermal pollution is a reduction in the amount of dissolved oxygen in water. The amount of any gas that can be dissolved in water varies inversly with the temperature (Henry's law). As water is warmed, therefore, it is capable of dissolving less and less oxygen. Organisms that need oxygen to survive will, in such cases, be less able to survive.

Water temperatures can have other less expected effects also. As an example, trout can swim less rapidly in water above 19°C making them less efficient predators. Organisms may become more subject to disease in warmer water too. The bacterium ***Chondrococcus columnaris*** is harmless to fish at temperatures of less than 10°C. Between temperatures of 10°–21°C, however, it is able to invade through wounds in a fish's body. At temperatures above 21°C, it can even attack healthy tissues.

The loss of a single aquatic species or the change in the structure of an aquatic community can have far reaching effects. Each organism is part of a food chain/web. Its loss may mean the loss of other organisms farther up the web who depend on it as a source of food.

The life in an aquatic ecosystem is greatly influenced by the growth of algae. Excess nutrients from wash out waters from farmlands combined with thermal pollution cause an excessive algae growth. This leads to acceleration of eutrophic and other undesirable effects. Moreover, the activities of pathogenic organisms are accelerated by higher temperatures. Thermal pollution thus makes the pathogens more virulent and the fish less resistant. As a consequence, pathogens vigorously attack fishes and a massive fish kill occurs.

[IV] Control of Thermal Pollution

Though the effects of thermal pollution are not so severe, control of thermal pollution is necessary since in future the effects may worsen. The use of water from a water course for cooling purposes, with subsequent return to the waterway after passage through the condenser is termed as *once-through cooling*. To reduce the magnitude of the pollution, the outlet water can be made to give up some of its heat to the atmosphere and then may be discharged into the water course. To make it effective, cooling towers are primarily used in many power plants and artificial lakes or cooling ponds are situated in some of the places.

(1) Cooling towers : Cooling towers transfer some of the heat from cooling water to the atmosphere, most probably through the evaporation of water. Evaporative cooling towers are of the following two types :

(a) Natural draft towers : In such towers, hot water is sprayed down through a rising current of air. The water vapour gives its heat to the counter-current air and gets cooled. The cooled water is collected at the bottom and returned to the water body. However, the installation and operation costs of such towers are high.

(b) Mechanical draft towers : In such towers, air flow is forced or induced by fans. Hot water during its passage to water course gets cooled by the action of air. However, these towers are not preferred, as they create annoyable noise due to the operation of fans and operation cost is also high.

Evaporative cooling towers cool the water by 10°C or more, but they evaporate nearly 2 percent or more of water during evaporation. One of the demerits of such towers is that they may form fo_3 under cold weather, creating driving hazards over an extended area. Similarly, in non-evaporative cooling towers, heat is transferred directly to the air by means of heat exchangers. It, however, involves high operational cost.

(2) Artificial lakes or cooling ponds : These are the man-made bodies of water which offer one possible alternative to *one-through cooling*. The heated effluents can be discharged into the lake at one end and the water for cooling purposes may be drawn at the other end since the heat would eventually be dissipated through evaporation, the cooling pond would have to be replenished continuously. Such cooling ponds are in use in some locations, but they are not a very attractive alternative since they require so much space. A one megawatt plant, for example, would require a cooling pond with 1000–2000 acres of surface area. In many areas, the cost of using land for this purpose would be too great to justify the procedure.

• 3.8. NUCLEAR HAZARDS

[I] Nuclear Pollution

Radioactive pollution of the environment is defined as the *increase in natural background radiation, emerging from the activities of man involving the use of naturally occurring or artificially produced radioactive materials.*

Radioactive pollution is both natural and man-made. The man-made sources of radioactive pollution are atomic power plants, nuclear weapon testing, recycling plants etc. Nuclear war materials and test explosions are the main sources of radioactive wastes. They produce radioactive isotopes and ionising radiations. Already over two thousand nuclear detonations must have been done in underground, under-ocean or in the atmosphere. The cumulative radioactivity level is rising, particularly in oceans. The two bomb blasts over Hiroshima and Nagasaki (1945) in Japan is still fresh in our memory. Besides a large number of deaths, the survivor not only suffered themselves but had malignant growths, cancers, congenital deformities, mental retardation. This is because besides effecting metabolic machinery, the radioactive substances cause rapid mutations.

Atomic plants are also responsible for radioactive pollution. This is because even a slight leakage of radioactivity in the coolant water will tend to accumulate and amplify in plants and animals. Columbia river which received coolant water from a plutonium reactor has enormous radioactivity. As compared to radioactivity in water, eggs of ducks have 10,000

times, some birds 75,000 times, plankton 1,200 times, fly larvae 40,000 times as much radioactivity. In case of radioactive phosphorus-32, the magnification of radioactivity is nearly 200,000 times.

It was observed by Woodwell that pines get destroyed on exposure to 20–30 rontgen/day, while an exposure of 200 rontgen/day, makes most plants die, except lichens and mosses.

The three most common radioactive elements received from radioactive wastes which enter the human body are iodine-131 (I^{131}), strontium-90 (Sr^{90}) and caesium-137 (Cs^{137}). They have half lives of 8·6 days, 28·5 years and 35·4 years, respectively. I^{131} gets stored in thyroid, Sr^{90} in bones, while Cs^{137} accumulates in the body muscles. Iodine-131 disrupts normal functioning of thyroid and produces abnormal growth and metabolism. Strontium-90 replaces calcium in metabolic activities, while caesium-137 replaces sodium and potassium in various metabolic activities and brings about genetic and functional changes. This pollution is most harmful for infants and childern. Radiation can cause cancer, abnormal births and mutations in man. Chronic exposure to radiations leads to leukaemia in an individual and even affects an unborn child in the womb.

Man is considered to be the final prey for radioactive pollution and is at the end of all reactions and interactions. Direct contamination occurs through exposure to radiations by the radioactive particles in air, radioactive gases and absorption of contaminants by respiration tract. Indirect contamination occurs by the consumption through food chain. It has been seen and tested that iron-55 is said to be accumulated in some fish varieties, zinc-65 has been accumulated in system at high levels, strontium-90 is said to be accumulated in certain marine animals. When these products are consumed by men, dangerous amounts of radioactive isotopes can get accumulated. Some sources of drinking water are also reported to contain radioactive materials, *e.g.*, radium-226, thorium-232, radon-222. Treatment processes may eliminate these radionuclides.

Modern life and habits also seem to increase the risks to own's life. The radiation from medical X-rays, colour T.V. sets, luminous dials of clocks and animals, X-ray fluoroscopes also contribute to these risks.

Due to nuclear explosions, oxides of nitrogen are formed in the atmosphere, which help in the destruction of ozone in the upper zone of the atmosphere. The use of satellites whose number exceed 800, have also increased radioactive pollution in the atmosphere.

The **International Commission on Radiological Protection** assessed the maximum permissible weekly dose for a radiation worker as 0·3 rem. (*For definition, see glossary*). The maximum permissible total dose for complete life time has been fixed as 200 rem which corresponds to 0.1 rem per week or 5 rem per year for continuous exposure. It has also been stated that strontium-90 and radium-226 should not exceed more than 3 and 10 pCi (*For definition, see glossary*) per litre, respectively.

[II] Control of Radioactive Pollution

The radioactive wastes which come out from industry, medicinal plants, nuclear reactors should be stored either in closed drums or in very large underground air tight cemented tanks. Moreover, the intermediate radioactive wastes should be disposed off into the environment after diluting it with some inert material. There should be a ban on nuclear explosions throughout the whole world. Concerted efforts are being made in this direction by several countries, including India.

Industrial wastes may be discharged into the environment, only after the necessary treatment so that the radioactivity is at a lower level. Wastes may be discharged into sewer system or into the streams. Before discharge, it is said that low activity wastes are stored for some time, so as to reduce the activity. In case of high activity wastes, they cannot be discharged. Now-a-days, small quantities of high activity wastes are converted into solids such as concrete and then it is buried underground or sea. According to recent survey, these wastes may also be converted into glassy or ceramic material which is then calcined to alumina or zirconia and leached. Disposal of wastes at sea has also been tried.

• 3.9. SOLID WASTE MANAGEMENT

[I] Causes of Solid Waste

Solid waste is composed of a broad array of materials discarded by households, businesses, industries and agriculture. The solid waste contains industrial non-hazardous waste, oil and gas waste, urban and municipal solid waste. Not all solid waste is actually solid; some semi-solid, liquid and gaseous wastes are included in the definition of solid waste. The **Resource Conservation and Recovery Act** defines solid waste to include garbage, refuse, sludge from municipal sewage treatment plants, ash from solid waste incinerators, mining waste, waste from construction and demolition and some hazardous wastes. Some hazardous waste may be disposed of in solid waste facilities. These include hazardous wastes discarded from households, such as paint, cleaning solvents and batteries and small quantities of hazardous materials discarded by business and industry.

Three quarters of industrial non-hazardous waste comes from four industries *viz.*, iron and steel manufacturers, electric utilities, companies making industrial inorganic chemicals and firms producing plastics and resins. About one-third of industrial non-hazardous waste is managed on the site where it is generated and the rest is transported to off-site municipal or industrial waste facilities. Although surveys conducted by some countries are beginning to fill in the gaps, there is still not enough landfills and surface impoundments for industrial solid wastes.

The materials in municipal solid waste (MSW) are discarded from residential, commercial, institutional and industrial sources. The materials include plastics, paper, glass, metals, wood, food and yard waste; the amount of each material is evaluated by weight or volume. The distinction between weight and volume is important when considering such factors as landfill capacity. For example, plastics account for only about 8 percent of MSW by weight, but more than 21 percent by volume. Conversely, glass represents about 7 percent of the weight and only 2 percent of the volume of MSW.

[II] Effects of Solid Wastes

Solid waste is a health hazard and can cause, damage to the environment if not handled properly. The main risk to human health arises mainly by the breeding of disease carriers, *e.g.*, flies, rodents, mosquitoes etc. Solid wastes are ideal breeding places for pathogens. In India, diseases like bacillary dysentry, amoebic dysentry and diarrhoea occur due to human faeces by flies to water or food and then to human beings on consumption. Refuse dumps serve as a source of food for rats and small rodents. Rats destroy property, infect by direct bite and spread dangerous diseases like plague, endemic typhus, trichinosis, salmonellosis etc. Workers are also threatened by handling and transfer of biological wastes, besides infection of diseases.

Improper disposal of solid waste results in the death of animals and humans through contamination of crops or water supplies. Wastes cause environmental damage, as uncontrolled dumping of urban solid waste destroys the beauty of the countryside. If the leachate from a refuse dump enters surface water or ground water, there is a fear of water pollution. Uncontrolled burning of open dumps may cause air pollution. Hazardous substances like pesticide and solvent cans, asbestos debris, medical wastes present in solid wastes, gaseous and particulate emissions from landfill areas and incinerators etc. cause environmental pollution.

[III] Control of Solid Wastes

(i) The disposal of MSW is only the most visible aspect of the waste disposal crisis. There are increasingly limited disposal options for all the solid waste generated. In response to this crisis, the Environmental Protection Agency in USA introduced a waste management hierarchy in 1989. The hierarchy places source reduction and recycling above incineration and land filling as the preferred options for managing solid waste.

(ii) Some solid wastes are potentially threatening to the environment if thrown away, but can be valuable resources if reused or recycled. Used motor oil is one example. It

contains heavy metals and other hazardous substances that can contaminate ground water, surfacewater and soils. These problems can, however, be avoided and energy saved, if used oil is re-refined into motor oil or reprocessed for use as industrial fuel.

(iii) Another solid waste with recycling potential are used tyres, which take up a large amount of space in landfills and cause uneven settling. Tyre stockpiles and open dumps can be breeding grounds for mosquitoes. They are hazardous if ignited, emitting noxious fumes that are difficult to extinguish. Instead of being thrown away, tyres can be shredded and recycled into objects such as hoses and door mats, they can also be mixed in road-paving materials or used as fuel in suitable facilities. Whole tyres can be retreaded and reused on automobiles or simply used for such purposes as artificial reef construction. Other solid wastes with potential for increased recycling include construction and demolition wastes (building materials), household appliances and waste wood.

(iv) ***Source reduction*** decreases the amount of waste created. It is considered the best solid waste management option and EPA defines it as reducing the quantity and toxicity of waste through the design, manufacture and use of products. Source reduction measures include reducing packaging in products, reusing materials instead of throwing them away and designing products to be long lasting. *Individuals can practice waste reduction by the goods they choose to buy and how they use these products once they bring them home.* Many businesses and industries have established methods for waste reduction and some have reduced waste toxicity by using less toxic materials in products and packaging. Source reduction can be part of an overall industrial pollution prevention and waste minimization strategy, including recapturing process wastes for reuse rather than disposal.

(v) Some state and local governments have chosen to conserve landfill space or reduce the toxicity of waste by instituting bans on the burial or burning of certain materials. The most commonly banned materials are automotive batteries, tyres, motor oil, yard waste and appliances. Where such bans exist, there is usually a complementary system in place for either recycling the banned materials or re-using them in some way. Programmes such as these usually compost yard waste and institute separate collections for hazardous waste.

(vi) Incineration : Incineration is the burning of waste in a specially designed combustion chamber. The idea of burning garbage is not new, but with the increase in knowledge about toxic chemicals known to be released during burning and with the increase in the amount of garbage to be burned, incineration now is done under controlled conditions. It has become the method of choice of many waste management companies and municipalities.

There are several types of combustion facilities in operation. At incinerators, mixed trash goes in one end unsorted and it is all burned together. The resulting ash is typically placed in a landfill. At mass burn incinerators, also known as *mass burn combustors*, the heat generated from the burning material is turned into usable electricity. Mixed garbage burns in a special chamber where the temperature reaches at least 1090°C. The by-products are ash (which is landfilled) and combustion gases. As the hot gases rise from the burning waste, they heat water held in special tubes around the combustion chamber. The boiling water generates steam and or electricity. The gases are filtered for contaminants before being released into the air.

One major problem with incineration is air pollution. Incinerators burning municipal solid waste produce the pollutants, *viz.*, carbon monoxide, sulphur dioxide and particulates containing heavy metals. The generation of pollutants can be controlled by proper operation and by the proper use of air emission control devices including dry scrubbers, electrostatic precipitators, fabric filters and proper stack height.

Ash is the solid material left over after combustion in the incinerator. It is composed of non-combustible inorganic materials that are present in cans, bottles, rocks and stones and complex organic materials formed primarily from carbon atoms that escape combustion. Municipal solid waste ash also can contain lead and cadmium from such sources as old appliances and car batteries. *Bottom ash*; the unburned and unburnable matter left over, comprises 75 to 90 percent of all ash produced in incineration. *Fly ash* is a powdery material

suspended in the flue gas stream and is collected in the air pollution control equipment. Fly ash tends to have higher concentrations of certain metals and organic materials and comprises 10 percent to 25 percent of total ash generated.

The greatest concern with ash is proper disposal and the potential for harmful substances to be released into the groundwater. The guidelines for handling ash include : ash containers and transport vehicles must be leak-tight, groundwater monitoring must be performed at disposal sites and liners must be used at all ash disposal landfills.

(vii) Composting and landfills. Solid waste can be disposed off in several ways by composting and landfills. In some ways, disposing waste in landfills is easier than the other methods. Most often, waste is compacted and dumped into excavated areas such as sand and gravel pits or in valleys. In sanitary landfills, waste is compacted each day and covered with a layer of dirt to decrease odour and discourage flies and other insects.

Surface and groundwater contamination have been noted in areas near lardfills. Because of these and other health related problems associated with landfill use, the Enviromental Protection Agency has recommended source reduction, recycling and incineration as the preferred waste management techniques over solid waste landfilling.

• 3.10. DISASTER MANAGEMENT

[I] Disasters

Floods, earthquakes, cyclones, landslides, fires, explosions, wars, riots, epidemics, leakage of hazardous chemicals etc. may be termed as ***disasters***, causing instantaneous damage on a large scale to the property, human life and environment. These uncertainties cannot be predicted with utmost accuracy. However, areas or locations, prone to each type of disaster, can be identified easily from the previous history of records. Coastal areas are more exposed to the fury of floods and cyclonic storms. Landslides, earthquakes are more likely to happen in mountain slopes and seismic zones of plateau regions. Flood waters stay for several days in agricultural fields and also submerge the whole human habitat.

Devastation caused by disasters :

(i) Human, animal and plant life or the entire ecosystem is lost.

(ii) Power, water and telecommunication systems fail.

(iii) Buildings and infrastructural facilities are badly damaged.

(iv) Road, railway and other transportation facilities collapse completely.

(v) Agricultural produce and cattle feed are damaged or spoilt beyond use.

(vi) Epidemic diseases, *e.g.*, cholera, gastroenteritis, plague etc. spread due to inadequate sanitation measures.

(vii) Economic and social disturbances are created after the disaster. It requires a lot of money, man power and time to restore normalcy. Rehabilitation becomes an enormous task.

[II] Earthquakes

One of the most bizarre effects of earthquake tremors is soil liquefaction. Soil with high water content is converted instantly to liquid mud. Buildings tipped over, hills slid into the valleys and animals sank as if caught in quickland. Some villages are flattened by earthquake, while others are flooded when the river fills in subsided areas. The earthquake is measured on the ***Richter scale.***

[III] Floods

Technically, floods occur when the water level in any stream, river, bay or lake rises above bank full. Bays may flood as the result of a tsunami or tidal wave induced by an earthquake or volcanic eruption or as a result of a tidal storm surge caused by a hurricane or tropical storm moving inland. Streams, rivers and lakes may be flooded by high amounts of surface runoff resulting from widespread precipitation or rapid snow melt. On a smaller scale, flash floods due to extremely heavy precipitation occurring over a short period of time can

flood streams, creeks and low lying areas in a matter of few hours. Thus, there are different temporal and spatial scales of flooding.

[IV] Cyclones and Tornados

A tornado is a vortex or powerful whirling wind, often seen as a funnel shaped cloud hanging from the base of a thunderstorm. It can be very violent and destructive as it moves across land in a fairly narrow path, usually a few hundred metres in width. Wind speeds are most often too strong to measure with instruments and are often estimated from the damage they cause. Winds have been estimated to exceed 350 mph (563 kph). Very steep pressure gradients are also associated with tornados and contribute to their destructiveness. Sudden changes in atmospheric pressure taking place as the storm passes sometimes cause walls and roofs of buildings to explode or collapse.

In some places, these storms are referred to as *cyclones*. Most cyclones occur between noon and sunset, when late afternoon heating contributes to atmospheric instability.

[V] Landslides

Landslide is a general term for the discrete downslope movement of rock and soil masses under gravitational influence along a failure zone. The term ***landslide*** can refer to the resulting land form as well as to the process of movement. Many types of landslides occur, and they are classified by several schemes, according to a variety of criteria. Landslides are categorised most commonly on the basis of geometric form, but also by size, shape, rate of movement and water content or fluidity. Translational or planar, failures such as debris avalanches and earth flows, slide along a fairly straight failure surface which runs approximately parallel to the ground surface. Rotational failures, such as rotational slumps, slide along a spoon shaped failure surface, leaving a hummocky appearance on the landscape. Rotational slumps commonly transform into earthflows as they continue downslope. Landslides are usually triggered by heavy rain or melting snow but major earthquakes can also cause landslides.

[VI] Prior Preparation of Cyclone Shelters

Construction of a special multipurpose cyclone resistant community centre or chain of shelters for providing safe and secure accommodation is a necessity in cyclone prone areas. These are constructed on an elevated ground with suitable provision of a community hall, kitchen, water, power, toilets, communications and other basic facilities. Bund protection as a flood control measure may be taken before monsoon sets in, with local people participation.

[VII] Information System

(i) Preparation of scientific database is very necessary for forecasting a disaster. Then only it is possible to communicate the possibility of an event and issue warning signals for taking all precautionary steps.

(ii) Preparation of database on population, houses, agricultural and aquaculture farms, cattle, socio-economic conditions of people etc. can help in assessing the quantum of risk.

[VIII] Preventive Measures

(1) Landslides along the mountain slopes can be reduced by :

(a) Avoiding unauthorised constructions.

(b) Afforestation to the maximum extent possible

(c) Providing suitable drainage systems.

(2) Floods can be prevented by :

(a) Construction of suitable bunds and strengthening the same.

(b) Developing suitable vegetation along the banks.

(c) Afforestation of the likely areas.

(d) Diverting excess water through cross drainage works.

(3) Cyclones and earthquakes can be prevented by :

(a) Proper building designs.

(b) Foundations, roofs, walls etc should be properly taken care while selecting the materials and methods of construction such that the structure is cyclone or earthquake proof.

[IX] Activities Before Disaster

(i) Training persons with regard to the evacuation of affected persons and distribution of food and medicines.

(ii) Arrangement of alternative shelter and communication works.

(iii) Mobilisation of medicines and relief materials.

(iv) Keeping fire, medical and ambulance services ready.

(v) Setting up of information centres.

(vi) Creation of public awareness and participation methodology.

[X] Relief Measures

(1) Immediately after the disaster, the first step is to cordon off the area, if possible, and maintain law and order with patience and presence of mind. The following relief measures should be undertaken :

(a) Rescue and relief operations.

(b) Rushing of medical teams of doctors.

(c) Supply of food, medicines and relief materials.

(d) Restoration of power, water asd telecommunication systems, as early as possible.

(e) Maintenance of sanitation.

(f) Safeguarding public properties, live-stock and agricultural products.

(g) Avoiding rumour and panic.

(h) Keeping the morale of the people high.

(2) After sometime has elapsed after the disaster, the following steps should be undertaken to restore normalcy and peace in the affected areas as follows :

(a) Removal of road blocks.

(b) Repair of damaged houses.

(c) Restoration of water, power, telecommunication, sanitation etc. facilities.

(d) Cleaning debris to take out the buried bodies.

(e) Rehabilitation of destitutes.

(f) Money, food and medicine be distributed with full honesty.

(g) All volunteers and rescue workers should act as a single team when any disaster strikes.

• 3.11. POLLUTION CONTROL

Pollution is becoming a gigantic problem day by day and it requires concerted efforts and cooperation not only from all governments of the world but also from industrialists, technologists, agriculturists etc. The human life is endangered by pollution. Every now and then international conferences have been held with the help of UNO and its subsidiary agencies to focus attention on the pollution problem and devise measures to reduce it. In 1971, in Stockholm, an international conference on ***'Human Environment'*** was held and it recommended several measures to be adopted by all world governments to combat the menace of pollution. In order to reduce the 'greenhouse effect', scientists recently (1997) assembled in Kyoto (Japan) to fight against the menace of environment pollution. Some of the recommendations were :

(i) To identify the causes of pollution so that protective measures be undertaken.

(ii) To find a neutraliser for each type of pollutant.

(iii) To identify areas where pollution and contamination are caused by poverty and illiteracy.

(iv) The use of anti-pollution measures by all industries.

(v) To know the carrying capacity of the environment.

(vi) To find out both short term and long term plans for controlling the pollution.

Some of the important methods to control pollution are :

(i) Installation of gobar gas plant where enough cow dung etc. is available.

(ii) Combustible solid wastes should be changed to fuel gases.

(iii) Solid organic wastes like faecal matter and tannery wastes should be converted into manure at places far away from living areas.

(iv) Proper sewage and sludge treatment methods be installed.

(v) Non-combustible, non-biodegradable and non-recoverable wastes be dumped in low lying areas for landfill.

(vi) Anti-smog devices be prepared or emission of smoke be reduced.

(vii) The smoke coming out of chimneys should be properly treated to remove solid carbon particles.

(viii) Detergents of low phosphate content should be used.

(ix) The use of fertilizers, pesticides etc. should be very judicious.

(x) Growing of plants, *e.g., coleus blumei, ficus variegata* etc., which are capable of fixing carbon monoxide.

(xi) Growing of plants, *i.e., crataegus, pyrus, pinus, vitis etc.*, which are capable of metabolising nitrogen oxide and other gaseous pollutants.

(xii) Inocculation of oil spill-over areas with oil metabolising bacteria.

Thus, a real assessment of the whole problem of pollution by the whole society is needed. Efforts should be made in the fields of :

(a) Revitalising the environment by making it greener, reducing public wastes discharges and efficient energy and material of usage.

(b) Reversing the trend of fast urbanisation and great inflow of people to industrial belts.

(c) Changing the value system.

In India, a number of institutions are working on pollution and its control. These are :

(i) National Environmental and Engineering Research Institute, Nagpur;

(ii) National Botanical Institute, Lucknow;

(iii) Central Drug Research Institute, Lucknow etc.

A number of laboratories under CSIR (Council of Scientific and Industrial Research) are also doing commendable work on environmental pollution control measures. A National Committee for Environment Protection and Control was instituted which now has several committees which review pollution periodically. On March 5, 1980, a meeting of eminent environmental scientists was held in Washington to fight this increasing menace of environmental pollution. All this is possible only if the public is well informed. There are well qualified people who can assess what is wrong with the environment to what extent and how it can be set right. They should take upon themselves to have a public opinion on this problem of global nature.

• SUMMARY

- Pollution is any change which adversely affects the biological and non-biological equilibrium of the environment.
- A pollutant is a substance or factor that when released into the environment has an actual or potential adverse effect on human interests.

- Pollutants which do not degrade or degrade very slowly in natural environments are called non-degradable pollutants, *viz.*, DDT, salts of lead, mercuric, cadmium etc.
- Bio-degradable pollutants are domestic wastes that can be readily decomposed under natural processes.
- Water pollution is the addition of something to water which changes its natural colour, odour or qualities and make it unfit for drinking.
- Domestic wastes and sewages, domestic detergents, pesticides and herbicides, industrial effluents, fuel gases, radioactive wastes etc. are the chief sources of water pollution.
- Biochemical oxygen demand (BOD) is the quantity of oxygen required for the oxidation of organic matter by bacterial action in presence of oxygen.
- Polluted water causes a number of infectious diseases like typhoid, dysentry, cholera, jaundice, skin diseases in human beings. It may also cause congenital deformities, anaemia, loss of appetite, bluish lines round the gums etc.
- Air pollution is the increase in concentration of undesired gases in the atmosphere. The main air pollutants are gases like carbon monoxide, carbon dioxide, sulphur dioxide, chlorine, ozone, ammonia, hydrocarbons, mercury vapours etc.
- Those pollutants which are mixed with air in the liquid or solid state and after sometime settle down at the surface of the earth are called particulate pollutants.
- Soil-pollution occurs due to the disposal of soild and semi-solid wastes from agricultural practices and from insanitary habits. Fall out from atmospheric pollution also contribute to soil pollution.
- When waste substances are discharged into the sea, they result in harm to living resources, hazards to human health, hindrance to fishery and deterioration of quality for use of sea water. This type of pollution is called **marine pollution.**
- A noise is defined as an unwanted sound. The loudness of sound is measured in terms of decibels.
- A decibel or dB is the unit of power level of a sound wave. A whisper has 20-25 dB noise level, whereas for Boeing 707, it is 160 dB.
- An increase in natural background radiation, emerging from the activities of man involving the use of naturally occurring or artificially produced radioactive materials is called **radioactive pollution.**
- A solid waste consists of broad array of materials discarded by households, businesses, industries and agriculture.
- A solid waste is a health hazard and can cause damage to enviromment if not handled properly. The main risk to human health arises mainly by the breeding of disease carriers, *e.g.*, flies, rodents, mosquitoes etc. Solid wastes are ideal breeding places for pathogens.
- Floods, earthquakes, cyclones, leakage of hazardous chemicals during wars etc. may be termed as **disasters.**
- Disasters may cause instantaneous damage on a large scale to property, human life and environment.

Student Activity

1. What are bio-degradable pollutants?

2. Name the types of water pollution.

3. Mention the harmful effects of water pollution on human beings.

4. What are particulate pollutants? Name any three of them.

5. How is soil pollution controlled?

6. Mention the harmful effects of noise pollution on human beings.

7. Write a note on earthquakes.

TEST YOURSELF

Answer the following questions :

1. What is pollution? Give examples of natural pollutants of air.
2. Discuss in brief, the causes, kind and control measures of pollution.
3. Give an account of the following :
   (a) Air pollution (b) Water pollution (c) Soil pollution
   (d) Noise pollution (e) Radioactive pollution.
4. Discuss briefly the air pollutants.
5. What are pesticides and weedicides? How do they affect our environment?
6. Mention briefly the measures adopted by national and international agencies to fight pollution.
7. Discuss the efforts of the Indian government to control pollution.
8. Name some of the Indian and international agencies working on pollution menace.
9. What is water pollution? Mention the water pollutants.
10. Describe major water pollutants and their removal.
11. What is the effect of water pollution on human beings, animals and plants.
12. What is soil? Discuss the composition of soil.
13. What do you understand by the terms : Humus, loam, litter.
14. How many types of soil water do you know?
15. Discuss the various sources of soil pollution. Classify soil pollution.
16. What controls can be taken to minimise soil pollution?
17. Give the different sources of radioactive contaminants and discuss them in detail.
18. Discuss the sources and effects of noise pollution.
19. What measures be taken to control noise pollution?
20. What is radioactive pollution? Discuss the measures to control it.

21. Write short notes on the following :
    (a) Noise pollution (b) Radioactive pollution or nuclear pollution
    (c) Biological contamination (d) Chemical contamination
    (e) Radioactive contamination
22. Explain the factors on which the noise pollution depends.
23. What are radioactive contaminants? Explain its various sources.
24. What are the sources of noise pollution? Discuss the various adverse effects of noise pollution on the human body.
25. Explain the sources of radioactive contamination.
26. Write an essay on radioactive contaminants.
27. Describe the adverse effects of noise pollution on the human body.
28. Name some important constituents of air. What is the approximate composition of air?
29. Write an essay on air pollution and its control.
30. Differentiate between gaseous and particulate pollutants.
31. Discuss the effect of air pollution on the following :
    (a) Human being (b) Animals (c) Plants
    (d) Climate (e) Buildings, monuments etc.
32. What are the different methods used for detecting and measuring air pollution?
33. How do the oxides of carbon, sulphur, nitrogen affect air pollution?
34. How does the nuclear explosions affect the environment?
35. Write short notes on the following :
    (a) Nitrogen cycle (b) Oxygen cycle
    (c) Water cycle or hydrological cycle (d) Carbon dioxide cycle.
36. Explain the composition of atmosphere and effects of the atmosphere gases on environmental pollution.
37. Increasing smoking in human society is an effective factor of air pollution and symbol of dangerous disease." Comment. Give your suggestions to control it.
38. Write short notes on the following:
    (i) Floods (ii) Earthquakes (iii) Cyclones (iv) Landslides.
39. What is disaster management? Discuss the devastation caused by natural disasters. Mention the relief measures to be undertaken during such disasters.
40. What is marine pollution? Discuss the causes, effects and control of marine pollution.
41. Explain thermal pollution. Mention the causes of thermal pollution and how it can be controlled?
42. Write an essay on solid waste management.
43. What do you understand by natural disasters? What measures you would take to prevent loss of lives from floods and earthquakes? Explain.
44. Explain the various methods commonly employed for the disposal of solid wastes with their advantages and disadvantages.
45. Write short notes on the following :
    (a) Incineration (b) Source reduction (c) Ash
    (d) Landfills (e) Flooding (f) Tornados
46. What are the causes of landslides? Discuss its consequences and suggest the methodology to fight back such hazards.
47. D.D.T. is :
    (i) Air pollutant (ii) Noise pollutant
    (iii) Bio-degradable pollutant (iv) Non-degradable pollutant

48. An air pollutant is :
(i) Sulphur dioxide, hydrocarbons (ii) Salts of mercuric and lead
(iii) Nuclear fall out (iv) Noise of aeroplanes, grinders etc.

49. The unit of noise pollution is :
(i) Cm (ii) Metre (iii) Nanometer (iv) Decibel

50. Soild waste can be removed by :
(i) Incineration (ii) Heating at low temperature
(iii) Cooling (iv) Evaporation

51. **Fill in the blanks :**
(a) Sea is the ..... source of water.
(b) Anaemia is caused by ..... pollution.
(c) Hydrogen fluoride is an ..... pollutant.
(d) Pneumoconiosis is caused by ..... pollution.
(e) The organic matter which undergoes partial decomposition to form a dark amorphous substance is called ..... .
(f) The combustion of fossil fuels causes ..... pollution.

ANSWERS

47. (ii), **48.** (i), **49.** (iv), **50.** (i),
51. (a) surface (b) water (c) air (d) air (e) humus (f) thermal

❑❑❑

UNIT

4

SOCIAL ISSUES AND THE ENVIRONMENT

STRUCTURE

- Sustainable Development
- Water Conservation
- Watershed Management
- Environmental Ethics
- Consumerism and Waste Products
- Urban Problems Related to Energy
- Rain Water Harvesting
- Resettlement and Rehabilitation of People
- Wasteland Reclamation
- Environmental Protection Acts
- Issues Involved During Enforcement of Environment Laws

❑ Summary ❑ Student Activity ❑ Test Yourself

LEARNING OBJECTIVES

After studying this chapter, you will learn about sustainable development, idea of rain water harvesting, environmental ethics and different environmental protection acts and laws.

4.1. SUSTAINABLE DEVELOPMENT

Sustainable development is a term first introduced to the international community by **'Our Common Future'**, the 1987 report of the World Commission on Environment and Development, which was chartered by the United Nations to examine the planet's critical social and environmental problems and to formulate realistic proposals to solve them in ways that ensure sustained human progress without depleting the resources of future generations. This Commission—chaired by Gro Harlem Bruntdland, Prime Minister of Norway and is consequently often called the **Bruntdland Commission**—defined sustainable development as, *"meeting the needs of the present generation without compromising the ability of future generation to meet their own needs"*. The concept of sustainable development in recent years has brought the realization that social perceptions must shift towards ecological determinism so as to obtain qualitative growth within the limits of the ecosystem's carrying capacity, which is quite necessary for achieving sustainable development. The goal of sustainable development, according to the Commission, is to create a new era of economic growth as a way of eliminating poverty and extending to all people the opportunity to fulfill their aspiration for a better life.

Something is sustainable if it is permanent, enduring, or can be maintained for the long term. Sustainable development then means improvements in human well being that can be extended or prolonged over many generations rather than just a few years. The hope of sustainable development is that if its benefits are truly enduring, they may be extended to all humans rather than just the members of a privileged group.

To obtain sustainable development, the following action strategies be observed.

(i) Control the population growth.

(ii) Reduce the wastage of matter and energy resources.

(iii) Conserve natural resources, *e.g.*, water, soil, forests, biodiversity etc.

(iv) Emphasis on pollution prevention and waste reduction.

(v) Composting, recycling and reusing nearly 60 percent by weight of matter from the resources we use.

(vi) Help sustain earth's biodiversity with emphasis on protecting vital habitats for wild species.

(vii) Use potentially renewable resources, *viz.*, water, soil, flora and fauna judiciously, less faster than they are renewed.

(viii) Shift to more dependence on locally available renewable energy from the sun, wind, rainfall and biomass.

(ix) Make things that last longer and can be easily reused, recycled and repaired.

• 4.2. URBAN PROBLEMS RELATED TO ENERGY

Natural energy sources have become scarce in the world due to the enormous increase in population. One of the impacts to be felt in future may be that fuel may become more expensive than food.We are marching towards empty gas cylinders and fire places without fire. The biological basis for survival is dwindling faster, while our every requirements are increasing. The increasing world population and decreasing energy resources, adds up to a situation that cannot continue for much longer.

Energy can be conserved in urban places by designing and constructing buildings so as to take advantage of natural heating and cooling factors in the environment. The buildings can be constructed partially underground. The earthern walls of these buildings provide a natural cooling effect in the summer and provide excellent insulation during the winter. The kind, number and placement of tress around a building can also contribute to energy efficiency. Energy can also be conserved by modifying appliances used within a building. Even items as simple as light bulbs can become a factor in energy conservation programmes. Government should penalise individuals and companies that use too much energy.

• 4.3. WATER CONSERVATION

Nearly 71 percent of the earth's surface is covered by water–an area called the hydrosphere, which makes up all of the oceans and seas of the world. Only 3 percent of the earth's entire water is freshwater. This includes Arctic and Antarctic *i.e.*, groundwater and all the rivers and freshwater lakes. The amount of usable freshwater is only about 0·003 percent of the total.

Water conservation may be accomplished by improving crop water utilisation efficiency and by decreasing the use of high water demanding crops and industrial products. Water utilization efficiency is measured by water withdrawal and water consumption. Water withdrawal is water that is pumped from rivers, reservoirs or groundwater wells and is transported elsewhere for use. Water consumption is water that is withdrawn and returned to its source due to evaporation or transpiration.

Xeriscape, the use of low water consuming plants is a most suitable landscape to conserve water, especially in dry, hot urban areas. Plants such as cacti and succulents, ceanothus which is related to foothill manzanita, trailing rosemary (*Rosemarinus officinale)* and white rock rose (*Cistus cobaviensis*) adapt well to hot, dry climates and help conserve water.

In addition to improving irrigation techniques, water conservation can be accomplished by improving domestic use of water. Such a conservation practice is the installation of the ultra-low-flush (ULF) toilets in homes and commercial buildings.

Another way to conserve the freshwater supply is to extract freshwater from sea water by ***desalinization***. Desalinization, the removal of soluble salts and other impurities from sea water by distlliation or ***reverse osmosis*** (RO) is becoming an increasingly acceptable method to provide high quality pure water for drinking, cooking and other home uses.

It is important that humans learn to live within the limit of available natural resources. Conservation of water alone will not extend the natural carrying capacity for an indefinite period of time, since the supply of available and usable water is finite, the consumption per person must be reduced. A permanent solution to the water shortage problem can be accomplished by living within the ecosystem carrying capacity or by reducing the number of consumers through effective control of population growth.

4.4. RAIN WATER HARVESTING

Water is an essential natural resource for sustaining environment and life of humans, animals and plants etc. **Rain water harvesting** is the ***utilization of rain water close to the point where rain reaches the earth.*** The Ministry of Water Resources in India has made rain water harvesting an integral part of everyday life. It has been divided as domestic rain water harvesting and rain water harvesting for erosion control, flood control, agriculture and aquifer replenishment.

[I] Objectives of Rain Water Harvesting

(i) To improve the quality of groundwater
(ii) To restore supplies from the aquifers
(iii) To store excess water for use later on
(iv) To reduce salinity ingress in coastal areas
(v) To prevent soil erosion and storm water runoff
(vi) To increase the subsoil water level
(vii) To reuse defunct wells after cleaning
(viii) To recycle urban and industrial waste waters
(ix) It is environment friendly
(x) To prevent flooding of roads etc.

[II] Components of Rain Water Harvesting System

The different parts of the rain water harvesting system are :

(i) Catchment area, *i.e.*, surface on which rain falls
(ii) Transport channels from catchment area to storage system
(iii) Storage tanks to store the rain water
(iv) Leaf screens and roof washers which act as parts to remove contaminants and debris
(v) Conveying the delivery system for treated rain water either by pump or gravity
(vi) Water treatment, which includes filters and other equipment as well as additives to settle, filter and disinfect the harvested water

[III] Advantages of Rain Water Harvesting

Following are the advantages of rain water harvesting :

(i) The groundwater level in wells is elevated
(ii) The water quality is improved
(iii) The effects of droughts can be mitigated to a large extent
(iv) The soil erosion and flood hazards are reduced
(v) The sea water ingress is arrested
(vi) It revives the traditional water harvesting systems
(vii) It assures the sustainability of the groundwater sources, urban and rural water supply systems
(viii) It upgrades the social and environmental status of the area and people living thereon

4.5. WATERSHED MANAGEMENT

Watershed management is defined as, *'planning, guiding and organizing land use so that desired goods and services are produced from a watershed (A catchment or drainage basin which is the total area of land that drains into a water body) without harming soil productivity and water resources.*

Goods and services produced from watersheds include food, forage for livestock and wildlife, wood and other forest products, outdoor recreation, wildlife habitat, scenic beauty and water. Essential to watershed management is the recognition that production must be accompanied by environmental protection.

[I] Objectives of Watershed Management

The specific objectives of watershed management depend on human needs in a particular area and can include :

(i) the rehabilitation of degraded lands

(ii) the protection of soil and water resources under land use system that produce multiple products of the land, and

(iii) the enhancement of water quantity and quality

Rehabilitating degraded lands is sometimes mistakenly thought of as the only role of watershed management. Rehabilitation requires that both the productivity and hydrologic function of degraded lands be restored. This usually entails the construction of engineering structures, such as gully controlled dams, followed by vegetation establishment, protection and management, all of which are needed to achieve long term healing of the landscape.

Most fundamental to watershed management is the prevention of land and water resource degradation in the first place. To achieve this goal, land use must adhere to conservation practices that avoid land degradation. The greatest potential for degradation arises from road construction, mining, crop cultivation, logging and overgrazing by livestock in steep terrain. When management guidelines are not followed, soils erode and land productivity is decreased. The loss of soil and vegetative cover reduces the effectiveness of watersheds in moderating the flow of water, sediment and other water borne substances. As a result, damage to aquatic ecosystems and human communities can occur in areas that are positioned downslope or downstream. To achieve sustainable land use, the development of and adherence to land use guidelines and conservation practices must become commonplace.

Preventing degradation of wetlands and riparian land is of particular environmental concern. These soil vegetation communities require special management and protection because the wet soils are susceptible to excessive erosion. Furthermore, riparian vegetation provides valuable wildlife habitat and plays a critical role in protecting water quality.

[II] Uses of Watershed Management

Watershed management can be used to enhance water resources. In some cases, vegetative cover can be altered to increase water yield or to change the pattern of water flow for beneficial purposes. Watershed management recognizes that human use of land is usually aimed at producing a variety of goods and services of which water is one product. By following the principles of water and soil conservation, land and natural resources can be managed for sustainable production with environmental protection.

4.6. RESETTLEMENT AND REHABILITATION OF PEOPLE

Rehabilitation is a process which is being applied more frequently to the humans and environment. It aims to reverse the deterioration of a national resource even if it cannot be restored to its original state. In an overpopulated country like India, the available land space is either already inhabited or under cultivation. Whenever, a project or an industry is likely to be set up, it occupies land and other resources, the persons are uprooted from their homes and leave their profession. The priority of the government is to rehabilitate and resettle the uprooted persons. Recently, in the construction of Tehri Dam (Uttaranchal) it is estimated that nearly 4600 hectare of forest land had submerged and 3,500 families have been displaced from their native place. Similarly, during the construction of Srisailam dam (Andhra Pradesh), Pong dam (Himachal Pradesh), Kali hydroelectric project (Karnataka), thousands of people have been uprooted making them refugees in their own homeland. Most of the affected persons are agricultural labourers, small farmers and others who are economically backward. It seems unlikely that they have received their share of money in compensation or alternate non-agricultural occupation.

Therefore, a sound national policy on rehabilitation and resettlement of affected people is necessary. The following points should be included in formulating such a policy.

(i) The extent of damage and suffering that the proposed project would cause and the number of people involved should be studied and evaluated before the commencement of the project.

(ii) The rehabilitation and resettlement work should be made a part of the project and all those affected should be rehabilitated before the start of the project.

(iii) The people should be rehabilitated on a *minimum dislocation basis* by selecting adjacent areas or locations.

(iv) The advantages of rehabilitation should be at the same level with those of the beneficiaries of the proposed project.

(v) The extent of rehabilitation and resettlement should meet the ends of social justice and balanced development.

(vi) Necessary help should be provided during shifting and reconstruction of alternative residential sites.

(vii) Vocational training and proper job opportunities be provided to displaced persons.

4.7. ENVIRONMENTAL ETHICS

Ethics is a branch of philosophy that deals with morals and values. *Environmental ethics refers to the moral relationship between humans and the natural world.* It addresses such questions as, do humans have obligations or responsibilities toward the natural world and if so, how are those responsibilities balanced against human needs and interest? Are some interests more important than others?

Efforts to answer such ethical questions have led to the development of a number of schools of ethical thought. One of these is utilitarianism, a philosophy associated with Jeremy Bentham and later modified by John Stuart Mill. In its most basic terms, utilitarianism holds that an action is morally right if it produces the greatest good for the greatest number of people. The early environmentalist Gifford Pinchot was inspired by utilitarian principles and applied them to conservation. He proposed that the purpose of conservation is to protect natural resources to produce the greatest good for the greatest number for the longest time.

The tenets of utilitarian philosophy are presented in terms of human values and benefits, a clearly anthropocentric world view. Many philosophers argue that only humans are capable of acting morally and of accepting responsibility for their actions. Not all humans, however, have this capacity to be moral agents. Children, the mentally ill and others are not regarded as moral agents, but rather as moral subjects. However, they still have rights of their own–rights that moral agents have an obligation to respect. In this light, moral agents have intrinsic value independent of the beliefs or interests of others.

Many environmental philosophers argue that we must also extend recognition of inherent worth to all other components of the natural world, both living and non-living. In their opinion, our anthropocentric view, which considers components of the natural world to be valuable only as the means to some human end, is the primary cause of environmental degradation. As an alternative, they propose a biocentric view which gives inherent value to all the natural world regardless of its potential for human use.

Issues and Their Solutions : Paul Taylor outlines four basic tenets of biocentrism in his book '*Respect for Nature*'. These are :

(1) Humans are members of earth's living community in the same way and on the same terms as all other living things.

(2) Humans and other species are interdependent.

(3) Each organism is a unique individual pursuing its own good in its own way, and

(4) Humans are not inherently superior to other living things.

The above tenets underlie the philosophy developed by Norwegian Arne Naess, known as deep ecology. From the above biocentric philosophy, Paul Taylor developed three principles of ethical conduct :

(1) Do not harm any natural entity that has a good of its own

(2) Do not try to manipulate, control, modify, manage or interfere with the normal functioning of natural ecosystems, biotic communitiies or individual wild organisms, and

(3) Do not deceive or mislead any animal capable of being deceived or misled.

These principles led Taylor to call for an end to hunting, fishing and trapping to espouse vegetarianism, and to seek the exclusion of human activities from wilderness areas. However, he did not extend intrinsic rights to non-living natural objects, and he assigned only limited rights to plants and domestic animals. Others argue that all natural objects living or not, have rights.

Ethical dilemmas arise when two different courses of action each have valid ethical underpinnings. A classical ethical dilemma occurs when any course of action taken will cause harm, either to oneself or to others. Another sort of dilemma arises when two parties have equally valid, but incompatible ethical interests. To solve such competing ethical claims, Paul Taylor suggested five guidelines :

(1) It is usually permissible for moral agents to defend themselves.

(2) Basic interests, those interests necessary for survival, take precedence over other interests

(3) When basic interests are in conflict, the least amount of harm should be done to all parties involved

(4) Whenever possible, the disadvantages resulting from competing claims should be borne equally by all parties, and

(5) The greater the harm done to a moral agent, the greater is the compensation required.

• 4.8. WASTELAND RECLAMATION

Land is an important resource since it is put to different uses by man. India has a land area of nearly $32 \cdot 88 \times 10^5$ km^2 which is about 2.4 percent of the world. About 44 percent of our land is used for agriculture, 23 percent is covered with forests, 4 percent is used for pastures and grazing fields, 8 percent for housing, agroforestry industrial areas, roads and so on. Nearly 14 percent land is barren and about 8 percent is used for miscellaneous purposes. The rapid increase of urbanisation and migration of population from villages to towns and cities have created several problems. All these factors led to the utilization of agricultural land for housing, construction, industries etc.

Wastelands are lands which are unproductive, unfit for cultivation, grazing and other economic uses due to rough terrain and eroded soils. The lands which are waterlogged and saline are also termed as wastelands. The deforestation leads to soil erosion and the eroded soils show drought like tendency. The felling of trees aggravate the lowering of water table and dry conditions. The loss of fertility followed by erosion also leads to the conversion of marginal forest lands into wastelands. In the absence of land management policy, geomorphic processes become active due to which soil layers are eroded and transported, making these lands infertile, stony and useless.

[I] Classification of Wastelands

The wastelands are broadly classified into two categories :

(1) Barren and uncultivable wastelands : These lands cannot be brought under cultivation or economic use except at a very high cost, whether they exist as isolated pockets or within cultivated holdings. Such lands are sandy deserts, gully land, stony or leached land, lands on hilly slopes, rocky exposures etc.

(2) Cultivable wastelands : These lands are not cultivated for five years or more. It consists of lands available for cultivation, but not used for cultivation. Next to fallow lands, cultivable wastelands are important for agricultural purposes, because they can be reclaimed through conservational methods for cultivation, grazing or agroforestry.

[II] Reclamation of Wastelands

The different methods used for the reclamation of wastelands are :

(i) These lands can be brought under cultivation by using excess water and fertilizers.

(ii) Afforestation and agronomical methods are used to conserve the soil, which help us to use it for agriculture.

(iii) Contour bunds are constructed which afford safe disposal of water of the catchment areas.

(iv) These lands can be used for settling the landless agricultural labourers.

• 4.9. CONSUMERISM AND WASTE PRODUCTS

The word consumerism means the consumption of resources by the people. The early human societies used to consume much less resources, but with the advent of industrial era, consumerism has shown manifold increase. It is related to :

(i) increase in the population size and

(ii) increase in our demands due to change in life style.

Earlier, we used to lead a much simpler life, and used to have fewer wants. In modern society our aspirations have risen, needs multiplied and so consumerism of resources has also multiplied.

The fast changing population trends influence consumerism of natural resources and generation of waste products. Two types of conditions of population and consumerism exist.

(1) Overpopulation of people : Overpopulation of people results in having more people than available supplies of water, food and other important resources in the area. The excessive population problem causes degradation of the limited resources and there is poverty, under-nourishment or malnutrition and starvation deaths. This mainly occurs in less developed countries (LDC). In such countries, due to large number of people, enough resources are not available for all. So, there is less per capita consumption, though overall consumption is high.

(2) Consumption overpopulation : This problem occurs in more developed countries (MDC), where population size is smaller and resources are in plenty. Due to luxurious life style, per capita consumption of resources is very high. More the consumption of resources, more is the waste generation and greater is the degradation of the environment.

The consumerism varies from country to country. United States of America (USA) is known for maximum consumerism. The population of India is nearly 3·5 times more than that of USA but its overall energy and waste products generation are less than one-eighth that of USA. Therefore, we can infer that more consumerism leads to more waste production and also pollution.

We can utilize the waste products for our benefits as summarized below :

(i) Paper from agricultural wastes

(ii) Cellulose from sugarcane bagasse

(iii) Medicines from agricultural wastes like corn cobs, oat hulls and bagasse.

(iv) Medium density fibre from dry agricultural stalks

(v) Proteins and sugars from cellulose waste

(vi) Use of flyash for making bricks, tiles and extraction of alumina

• 4.10. ENVIRONMENTAL PROTECTION ACTS

The Environment Protection Act, 1986 was enacted as per the spirit of the Stockholm Conference (June, 1972) to initiate appropriate steps for the protection and improvement to

prevent hazards to human beings, animals and property. This legislation protects the environment and plug the loopholes in the eartier laws. This Act empowers the Central Government to issue directives :

(i) For the closure, prohibition or regulation of any industry, operation and process, and

(ii) For the stoppage or regulation of the supply of water, power or other essential services, even without obtaining orders from the Hon'ble courts.

The Act also empowers the Central Government to make rules for :

(i) Maximum permissible limits of concentration for different environmental pollutants, including noise

(ii) Maintaining the standard of quality of water, air and soil for different areas

(iii) Procedures and safeguards for handling the toxic substances

(iv) Prohibition and restrictions on the location of industries

(v) Procedures and safeguards for prevention of accidents causing environmental pollution

The Act provides for stringent punishment and penalties for defaulters not obeying the law and spirit of the Act.

[I] Air (Prevention and Control of Pollution) Act 1981

The Act deals with the preservation of air quality and the control of air pollution with a concern for the detrimental effects of air pollutants on human health and also on the biological world. In 1987, important amendments to the Air Act, 1981 were made and noise was recognized as an air pollutant.

[II] Water (Prevention and Control of Pollution) Act, 1974

This Act deals with the preservation of water quality and the control of water pollution with a concern for the detrimental effects of water pollutants on human health and also on the biological world.

The Act, amended in 1988, prohibits disposal of any poisonous, noxius or polluting matter to the flow of water in a stream. However, dumping of any material into a stream for the purpose of reclamation of land is not considered an offence.

The Act stipulates the establishment of Central and State Water Boards. These boards have the power to obtain information, to take samples of effluents from any industry and to survey any area and keep record of the volume and other chracteristics of any well, river or stream etc.

The Act provides severe and stringent punishment for its violation which includes fine or imprisonment or both.

[III] Wildlife (Protection) Act, 1972 (Amended 1991)

This Act provides for protection of wild animals, birds and plants and includes the following objectives :

(i) Restriction and prohibition on hunting of animals

(ii) Protection of specified plants

(iii) Setting up and managing national parks and wildlife sanctuaries

(iv) Empowering zoo authorities with control of zoos and captive breeding, and

(v) Control of trade and commerce in wildlife, wildlife products and trophies

Penalties for violating the provisions of the Act have been mentioned in the Act.

[IV] Forest Act, 1927

The Act aims to consolidate the law relating to forests and its basic objectives are as follows :

(i) Setting up and managing reserved forests, protected forests and village forests

(ii) Protection of non-government forests and forest land

(iii) Control of movement of forest produce, and

(iv) Control of cattle grazing.

[V] Forest Conservation Act, 1980 (Amended 1988)

The principal aim of this Act is to ensure environmental stability and maintenance of ecological balance including atmospheric equilibrium which are vital for all life forms, human, plant and animal. The derivation of direct economic benefit *e.g.*, production of wood and other materials is considered subordinate to the principal aim. This Act stipulates that no forest land may be used for any non-forest purposes without the prior permission of the Central Government. Land used for non-forest purposes include cultivation of tea, coffee, rubber, palms, horticulture crops, oil bearing plants and medicinal plants.

• 4.11. ISSUES INVOLVED DURING ENFORCEMENT OF ENVIRONMENT LAWS

The environmental issue in India looks gloomy despite so many legislations and Acts. The rivers and the lakes continue to be choked with industrial wastes and sewage. The air in several cities of India is heavily polluted. Deforestation takes place quite normally. The protection of wildlife is not carried out in its true spirit, despite the enforcement of Acts.

The people must be guided and helped to establish the trend of acceptance of preventing the environment from being polluted. Environmental litigation is more expensive than other types of disputes, as it involves expert testimony and technical evidence—central and state boards must be able to afford the expertise and the administrative backing. An effort should always be made for out-of-court settlement in environmental legal disputes. But in India, such settlements may increase the perennial problem of corruption. So, efforts be made to share the costs of anti-pollution measures taken by the industry to aviod state sponsored expensive and lengthy legal battles. The laws enacted by the government should be made very stringent and harsh so that citizen of India may not dare to play with the environment and instead he/she should protect it.

Public awareness : The increasing awareness of environmental issues has generated great activity in recent years. It has also brought to the knowledge of common citizens of India that for sustaining agriculture and maintaining the quality of environment at least one third of the country's land should be under forests. This public awareness has helped government as well as voluntary organizations to take up the issue of environmental protection. People and activists agitation in connection with Chipko Movement, Appiko Movement, Silent Valley (Kerala) and Sardar Sarovar Project on Narmada are some illustrations to show how the general public is aware of the fact that the environment should be clean and pollution free.

Environmental education is fast emerging as one of the most important disciplines in the world. Merging the ideas and philosophy of environmentalism with the structure of formal education systems, it strives to increase awareness of environmental problems as well as to foster the skills and strategies for solving those problems. Nature education expanded the teaching of biology, botany and other natural sciences out into the natural world, where students learned through direct observation. Both governmental and citizen entities included an eductional component to spread their message to the general public. Many states required their schools and colleges to adopt environmental conservation education as part of their curriculum so that they are prepared to deal with environmental problems in the real world. Teaching training programmes were developed to meet the increasing demand.

With the fast growing industrial output and natural resource depletion following World War II, people began to see the potential environmental disasters looming ahead. The environmental movement exploded upon the public agenda in the late 1960s and early 1970s, and the public reacted emotionally and vigorously to isolated environmental crises and events. Yet it soon became clear that the solution would involve nothing short of fundamental changes in values, lifestyles and individual behaviour and that would mean a comprehensive educational approach.

William Stapp observed that environmental education is aimed at producing a citizenry that is knowledgeable concerning the biophysical environment and its associated problems, aware of how to help solve these problems and motivated to work toward their solution.

• SUMMARY

- Meeting the needs of the present generation without compromising the ability of future generation to meet their own needs is called sustainable development.
- Water can be conserved by improving crop water utilisation efficiency and by decreasing the high water demanding crops.
- Rain water harvesting is the utilisation of rain water close to the point where rain reaches the earth.
- Rain water harvesting improves the quality of groundwater, to store excess of water for further use, to increase the subsoil water level, to prevent flooding of roads etc.Planning, guiding and organizing land use so that desired goods and services are produced from a catchment or drainage basin without harming soil productivity and water resources called watershed management.
- The main objectives of watershed management are rehabilitation of degraded lands, protection of soil and water resources, increase of water quantity and quality.
- Wastelands are lands which are unproductive, unfit for cultivation, grazing and other economic uses due to rough terrain and eroded soils. Lands which are waterlogged and saline are also termed as wastelands.
- Reclamation of wastelands can be brought about by :
  (i) Using excess water and fertilizers.
  (ii) Using agronomical and afforestation.
  (iii) Settling the landless agricultural labourers.
  (iv) Constructing contour bonds which afford safe disposal of water of the catchment area.

• Student Activity

1. Discuss the sustainable development.

2. Mention two objectives of watershed management.

3. What are environmental ethics?

4. Classify wastelands.

5. State air pollution act.

• TEST YOURSELF

Answer the following questions :

1. State and explain sustainable development.
2. What are the recent approaches to achieve sustainable development?
3. Discuss major causes of wastage of water resources. How can water be conserved?
4. What are wastelands? Name and discuss the various methods of wasteland reclamation.
5. Discuss briefly the salient features of the Forest (Conservation) Act, 1980.
6. Describe the urban problems which are related to energy.
7. What are the problems faced during the rehabilitation and resettlement of people?
8. Discuss the significance of rain water harvesting and watershed management.
9. Describe the issues involved in the enforcement of environmental legislation.
10. Write notes on the following :
    (i) Water conservation
    (ii) Rain water harvesting
    (iii) Public awareness regarding environment problems
11. Explain the following :
    (i) Environment Protection Act.
    (ii) Air (Prevention and Control of Pollution) Act.
    (iii) Water (Prevention and Control of Pollution) Act.
    (iv) Wildlife Protection Act.
12. Define consumerism and its relation to waste products.
13. Discuss briefly the environmental ethics and related issues with their solutions.
14. What is 'rain water harvesting'? Name and discuss in brief the types of rain water harvesting.
15. Briefly discuss the objectives of Resettlement and Rehabilitation Policy.
16. Briefly discuss the salient features of Environment (Protection) Act, 1986.
17. Rain water harvesting :
    (i) Prevents soil erosion (ii) Improves quality of ground water
    (iii) Makes environment ecofriendly (iv) All the above
18. **Fill in the blanks :**
    (a) Population growth can be controlled by ..... development.
    (b) The area where the rain water falls is called ..... area.

ANSWERS

17. (iv), **18.** (a) sustainable (b) catchment.

UNIT

5

HUMAN POPULATION, ENVIRONMENT AND ENVIRONMENTAL MANAGEMENT

STRUCTURE

- Population Growth
- Environment and Human Health
- Human Rights
- Women and Child Welfare
- Family Welfare Programmes
- HIV/AIDS
- Value Education
- Role of Information Technology in Environment and Human Health
- Concept of Ecological Balance
- Measures for Ecological Balance

☐ Summary ☐ Student Activity ☐ Test Yourself

LEARNING OBJECTIVES

After studying this chapter, you will learn about population growth and family welfare programmes. You will also get an elementary idea about HIV/Aids and its cure. You will also learn about human rights and role of IT in human health, concept of ecological balance and its measures.

• 5.1. POPULATION GROWTH

A population is all of the members of a species that occupy a particular area at the same time. The human population growth is responsible for most of our ecological problems, *e.g.*, our steadily diminishing energy supply and the pollution of water and air. The reason is that humans constitute the most abundant species comparable only to certain insects or fishes. The human population is adapted to all climatic conditions, has a very wide range of distribution and in all seasons remain reproductively active. The human birth is regulated by socio-economic factors.

The human population is increasing at an alarming rate. The main feature of human population growth is that it is more stable in developed countries. The birth rate and death rate is low in countries like Germany, France and USA. In Bangladesh, China and India, the growth of human population is quite high. So, there is an inverse relationship between industrial development and education and the population growth.

[I] Annual Average Growth Rate

The human population growth rate is determined in terms of annual average growth rate, calculated according to the formula,

$$\text{Annual average growth rate (in \%)} = \left(\frac{P_2 - P_1}{P_1 \times N}\right) \times 100$$

where P_1 and P_2 represent the population size in the previous and present census, respectively, N is the number of years between the two census.

[II] Factors Affecting Population Growth

The population growth is affected by the following factors :

(1) Birth rate (or natality) : In the human population, the birth rate affects and increases its size.

(2) Death rate (or mortality) : Increasing death rate controls or stabilises the human population.

(3) Immigration : The process of movement of people into a population from outside is known as immigration. It tends to increase population.

(4) Emigration : The process of movement of people outside a population is known as emigration. It tends to decrease the population.

(5) Change in environmental factors : Availability of large amount of food materials and water and enough space to live in for its members tend to increase the size of population. When population growth occurs, scarcity of nutrition and paucity of space develop, which lead to mass movement of individuals away from such place. It then decreases birth rate eventually controlling the population growth.

Malthus (1798) in his famous '*Eassy on Population*' stated that uncontrolled population tends to increase in geometric ratio, while the demand of food supply increases in arithmetic mean. A drastic change in environment can destabilise or sometimes exterminate the population.

(6) Biotic factors : Some biotic factors influence the population size, *e.g.*, pathogens causing epidemic or endemic diseases or on the basis of food habits.

(7) Abiotic factors : A population growth is influenced by abiotic factors like temperature, rainfall, humidity, intensity of sunlight.

[III] Zero Population Growth

The stage when the number of individuals added to the population equals the number of individuals lost and the population remains constant, is known as zero population growth.

[IV] Demography

That special branch of study which is related to the trends in human population growth and predictions of future development is called **demography.** It involves collection of data concerning economic and social status, age groups, education, employment, religious beliefs, family structure, number of births, urban and rural background of different sets of persons.

It has been observed that a decrease in a country's birth rate follows a reduction in death rate. This decline/decrease in birth rate is known as **demographic transition.** The single factor that is most clearly related with a lowered birth rate is an increase in the level of education and employment of women.

[V] Variation Among Nations

The human population is increasing at the rate of 2 percent every year. In the world, Bangladesh has the highest population density, while Australia has the least. The doubling time of population varies greatly from one nation to another. Population growth is fastest in those countries which are poorest and can least afford it. It took from the time of the first human being evolved on earth until 1830, for the human population to reach one billion. But in only 100 years from 1830 to 1930, the population doubled to 2 billions. From 1930-1960, *i.e.*, 30 years, the third billion was added . By 1975, the human population exceeded four billions. The doubling time for world population is now only 35 years. By the year 2000, about eight billions people had crowded our planet.

[VI] Population Explosion

The human population continues to increase not only enormously but at an alarming rate. The demographic transition has always taken from one to three generations to spread through the population in any nation. During its progress, the death rates are low, but birth rates remain high, as a result of which the human population increases alarmingly.

If the present trend of population growth continues, the available natural resources will fall short to meet the humans needs. A severe competition is likely to develop which will lead to several socio-economic problems like hunger, unemployment, poverty, lack of basic amenities, education. All this will lead to misery of mankind. Nearly 20,000 people die of starvation and at least ten million children in the world suffer from malnutrition.

At present, the world population is increasing at the rate of 2 persons per second, 2,00,000 persons per day, 8 million persons per month or 70 million persons per year. Such a

tremendous fast population growth rate of humans is known as **population explosion** or **population holocaust.**

• 5.2. FAMILY WELFAFE PROGRAMMES

If the population continues to grow at the present rate, the earth would soon become severely over-crowded and uninhabitable. Before the human population faces acute hunger, poverty, ill health, shortage of space, lack of education and living space, leading to struggle for mere existence, and such factors assume disastrous shape, we will have to plan seriously to control the human population.

[I] Birth Control Measures

In order to control the population growth, measures to control it should be adopted. The safe reversible, inexpensive, efficient and acceptable methods of birth control or contraception should be adopted very seriously. Our government and mass media are doing a good job in spreading the message to the masses emphasizing on the healthy attitude towards birth control or family welfare programmes. A number of scientific methods can be used for funiting the fertility, birth control and contraception.

(1) Prevention of pregnancy : By the use of hormones, the production of eggs (ova) can be suppressed in women and so the pregnancy can be avoided. It can be achieved by *oral contraceptive pills* taken by women which change their ovulatory cycle.

(2) Prevention of fertilization : The fertilization of egg (ovum) by sperm can be prevented by the following methods.

(i) ***Condom*** : It is used by man which prevents release of sperms into the vagina.

(ii) ***Intra uterine contraceptive device (IUCD)*** : It is achieved by using a loop or copper T inserted into utreus which prevents fertilization.

(iii) ***Spermicidal creams*** : Such creams on application by women form a jelly like medium in uterus which retards the activity of sperms and prevents fertilization.

(iv) ***Vaginal diaphragm*** : It prevents sperms from reaching upto the eggs to prevent fertilization.

(v) ***Surgical operation.*** In women surgical operation like *tubectomy* or *tubal ligation* and in men *vesectomy* are easy and safe methods to prevent fertilization. In men, cutting or tightening of *vas deferens* prevents the release of sperms into the semen. In women, by operation, ova or eggs are prevented to enter in uterus by cutting or tightening the fallopian tube.

(3) Abstinence : The pregnancy can be stopped by self control.

(4) Medical termination of pregnancy : The undesired pregnancy can be terminated by abortion, which has now been legalised.

It is to be noted that the above measures must be carried out under the supervision of a qualified medical practitioner, otherwise they are liable to pose social probelms.

• 5.3. ENVIRONMENT AND HUMAN HEALTH

Environmental health is concerned with the medical effects of chemicals, pathogenic (disease causing) organisms or physical factors in our environment. Because our environment affects nearly every aspect of our lives in some way or other, environmental health is related to every branch of medical science. The special focus of this discipline, however, tends to be health effects of polluted air and water, contaminated food and toxic or hazardous materials in our environment.

For a majority of humans, the most immediate environmental health threat has always been bathogenic organisms. Improved sanitation, nutrition and modern medicine in the industrialised countries have reduced or eliminated many of the communicable diseases that once threatened us. But for people in the less developed countries where nearly 80 percent of the world's population lives, bacteria, viruses, fungi, parasites, worms, flukes and other

infectious agents remain major causes of illness and death. Hundreds of millions of people suffer from major diseases like malaria, gastrointestinal infections (dysentry, diarrhoea, cholera), tuberculosis, influenza and pneumonia spread through air, water or food. Many of these terrible diseases could be eliminated or greatly reduced by a cleaner environment, inexpensive dietary supplements and better medical care.

For the billion or so richest people in the world—including most of the population of the United States and Canada—diseases related to lifestyle or longevity tend to be much greater threats than more conventional environmental concerns such as dirty water or polluted air. Heart attacks, strokes, cancer, depression and hypertension, traffic accidents, trauma and AIDS lead as causes of sickness and death in wealthy countries. These diseases are becoming increasingly common in the developing world as people live longer, exercise less, eat a richer diet and use more drugs, tobacco and alcohol. Epidemiologists predict that by the middle of this century, these diseases of affluence will be leading causes of sickness and death everywhere.

Although a relatively minor cause of illness compared to the factors above, toxic or hazardous synthetic chemicals in the environment are becoming an increasing source of concern as industry uses more and more exotic materials to manufacture the goods we all purchase. There are many of these compounds to worry about. Some of the materials have been thoroughly tested for toxicity. Furthermore, the process of predicting what our chances of exposure and potential harm might be from those released into the environment remains highly controversial. Toxins are poisonous, which means that they react specifically with cellular components or interfere with unique physiological processes. A particular chemical may be toxic to one organism but not another or dangerous in one type of exposure but not others. Because of this specificity, they may be harmful even in very dilute concentrations. Ricin, for example, is a protein found in castor beans and one of the most toxic materials known. A single molecule can kill an individual cell. It has been studied that three hundred picograms (trillionths of a gram) injected intravenously is enough to kill an average mouse. If humans were as sensitive as mice, a few teaspoons of this compound divided evenly and distributed uniformly could kill everyone in the world. By the way, this points out that not all toxins are produced by industry. Many natural products are highly toxic.

Toxins that have chronic (long lasting) or irreversible effects are of special concern. Among some important examples are neurotoxins (attack nerve cells), mutagens (cause genetic damage), teratogens (result in birth defects) and carcinogens (cause cancer). Many pesticides and metals such as mercury, lead and chromium are neurotoxins. Loss of even a few critical neurons can be highly noticeable or may even be lethal, making this category of great importance. Chemicals or physical factors such as radiation that damage genetic material can harm not only cells produced in the exposed individual but also the offspring of those individuals as well.

Inspite of the foregoing discussion of the dangers of chronic effects from minute exposures to certain materials or factors, not all pollutants are equally dangerous nor is every exposure an unacceptable risk. Our fear of unknown and unfamiliar industrial chemicals can lead to hysterical demands for zero exposure to risks. The fact is that life is risky. Furthermore, some materials are extremely toxic, while others are only moderately or even slightly so.

This is expressed in the adage of the German physician, Paracelsus (1540) who stated that '***the dose makes the poison***'. It has become a basic principle of toxicology that nearly everything is toxic at some concentration but most materials have some lower level at which they present an insignificant risk. Sodium chloride (table salt), for example, is essential for human life in small doses. If you were forced to eat a kilogram all at once, however, it would make you very sick. A similar amount injected all at once into your blood stream would be lethal.

The movement, distribution and fate of materials in the environment are important aspects of environmental health. Solubility is one of the most important characteristics in determining how, when and where a material will travel through the environment and into our bodies. Chemicals that are water soluble move more rapidly and extensively but also are

easier to wash off, excrete or eliminate. Oil or fat soluble chemicals may not move through the environment as easily as water soluble materials, but may penetrate very efficiently through the skin and into tissues and organs. They also may be more likely to be concentrated and stored permanently in fat deposits in our body.

The most common route of entry into our body for many materials is through ingestion and absorption in the gastrointestinal (GI) tract. The GI tract, along with urinary system are the main routes of excretion of dangerous materials. Not surprisingly, those cells and tissues most intimately and continuously in contact with dangerous materials are among the ones most likely to be damaged. Ulcers, infections, lesions or tumors of the mouth, esophagus, stomach, intestine, colon, kidney, bladder and associated glands are amongst the most common manifestations of environmental toxins. Other common routes of entry for toxins are through the respiratory system and the skin. There also are important routes for excreting or discharging unwanted materials.

It is difficult to determine responses to very low levels of particular chemicals, especially when they are not highly toxic. The effects of random events, chance and unknown complicating factors become troublesome, often resulting in a high level of uncertainty in predicting risk. The case of sweetner '*Saccharin*' is a good example of complexities and uncertainties in risk assessment. Studies in 1970s, suggested a link between saccharin and bladder cancer in male rats. Critics pointed out that humans would have to drink 800 cans of soft drink per day to get a dose equivalent to that given to the rats. Further more, they argued that most people are not merely large rats.

Inspite of the seriousness of the concerns expressed above, the Environmental Protection Agency (EPA) warns that we need to take a balanced view of environmental health. The risks associated with allowable levels of certain organic solvents in drinking water or some pesticides in food are thought to carry a risk of less than one cancer in a million people in a lifetime. Many people are outraged about being exposed to this risk, yet they cheerfully accept risks thousands of times as higher from activities they enjoy such as smoking, driving a car or eating an unhealthy diet. According to EPA, the most important things we as individuals can do to improve our health are to reduce smoking, drive safely, eat a balanced diet, exercise reaonably, lower stress in our lives, avoid dangerous jobs, lower indoor pollutants, practice safe sex, avoid sun exposure and prevent household accidents. Many of these factors over which we have control are much more risky than the unknown, uncontrollable, environmental hazards we fear so much.

• 5.4. HIV/AIDS

The AIDS (Acquired Immuno Deficiency Syndrome) story started in the USA in June 1981, when a rare type of pneumonia was detected in five young homosexuals. This disease has now taken the proportions of an epidemic. Two Americans Max Essex and Robert Gallo (1983) described that the Human T Leukemia virus (HTLV type III) could be the agent for AIDS. This virus belongs to the group of retrovirus, many of which cause cancer or leukemia. This virus has been given different names–Aids Associated Retrovirus (ARV), Lymphadenopathy Associated Virus (LAV), but it has recently been given the name of Human Immuno Deficiency Virus (HIV). It is likely that HIV exists in several strains in different parts of the world.

[I] Position of HIV in World and India

According to WHO (1990) report, nearly 8 million people infected with HIV, of which 40 percent are women, existed in the world. By the end of 1995, the number of HIV positive persons over worldwide swelled to 25 million adults and 1·5 million children. In Asia, Thailand was among the first country to fall victim to AIDS. In India, AIDS virus was first reported in 1986 among ten prostitutes in Chennai. According to UN AIDS report (2000), HIV population in India was as high as 4·5 million (second highest in the world). The four states having the highest HIV positive cases are Maharashtra, Tamilnadu, Manipur and Punjab.

[II] Causes

The main reasons of the high rate of increase of AIDS incidence in India are :

(i) Alarming extent of ignorance and prejudice about the disease.
(ii) False perception of this disease being contagious.
(iii) Reluctance of medicos to treat the affected persons.
(iv) Medical confidentiality and sexual behaviour.
(v) Inadequate screening facilities.
(vi) Inadequate monetary funding.
(vii) Low female literacy rate.

[III] Modes of Transmission

AIDS is not a contagious disease. It does not spread through contact, caring of infected persons, light kissing and living together, coughing, sneezing and spitting, eating together in a single dish, blood sucking insects, by common use of toilets, swimming pools, clothes etc.

The main sources of epidemiology of HIV are :

(i) Sexual intercouse.
(ii) Use of contaminated hypodermic needles and syringes.
(iii) Blood transfusion.
(iv) Organ transplantation.
(v) Artificial insemination from infected mother to baby during parturition and breast feeding.

[IV] Symptoms

The symptons of AIDS include chronic fever, persistent swelling, lymphatic ganglions (lymphadenopathy), accompanied by nocturnal sweating, diarrhoea, loss of weight etc. The AIDS patients also become more susceptible to infections of any system of body. When brain is damaged, then it may cause loss of memory, ability to speak and even to think. A full fledged AIDS patient dies within three years and mortality rate is 100 percent.

[V] Diagnosis

AIDS can be diagnosed by ***Elisa test*** and ***Western Blot test***. These tests give results only 2 to 24 weeks after the HIV infection, because no antibodies are produced during this window period. The Elisa test is based on antigen antibody and enzyme-substrate reactions.

[VI] Mechanism of AIDS

Humans have a disease defence mechanism, an immune system. The invading microbes are generally killed by lymphocytes T and B. In fact, T lymphocytes and mainly T_4 lymphocytes (carrying a glycoprotein) proliferate during every ordinary infection and if a person contracts a viral infection at such a time, the virus finds a very conducive environment for its growth, because it exclusively develops in T_4 lymphocytes. The virus multiplies inside them and finally disintegrates them. The liberated virus enters fresh lymphocytes to repeat the cycle, till all lymphocytes are killed. Thus, the immune system of the patient collapses, reaching a defenceless state, called AIDS.

[VII] Preventive Measures and Therapy

No absolutely satisfactory vaccine has yet been developed to cure the HIV infection. The management of AIDS depends on preventive measures, *e.g.*, educating the people especially of high risk groups, use of disposable needles and syringes, screening tests for donor of blood, organs, semen etc., having mutually faithful monogamous relationship and avoiding prostitution, multipartner sex and homosexuality and using of condoms. The spread of AIDS can best be prevented by having a life long monogamy and use of disposable needles and syringes.

There are no curative methods to control AIDS. The spread of the disease can be greatly checked by development of tests to identify persons harbouring HIV virus. Efforts are

made for creating a vaccine against the virus which is urgently required to stop the spread of this deadly disease.

December 1, is observed as World AIDS Day throughout the world.

• 5.5. HUMAN RIGHTS

Indian Constitution gives us civil, social, cultural, educational, political rights including the right to judicial enforceability. At the international level, the United Nations adopted the **'Declaration of Human Right, 1948'** which has made efforts to promote and encourage respect for human rights and fundamental freedom irrespective of race, sex, language or religion. They have ranged from standard setting to monitoring from facilitating international dialogue and cooperation to provide technical assistance and from commissioning technical studies in deploying large scale peace keeping missions.

In order to create awareness about the human rights, the people should be educated. The UN has started efforts to promote human rights education with the main objective of teaching of '*common language of humanity*' to the people and make a universal culture of human rights.

The promotion of human rights through education involves :

(i) Knowledge about one's rights.

(ii) Values, beliefs and attitudes promoting an action.

(iii) Elimination of prejudices.

(iv) Developing a positive attitude towards establishing a peaceful and harmonious society.

The human rights activists, women's wings and legal associations are actively promoting human rights education worldwide. In India, human rights education got importance will the highlighting of weaker sections, cases of custodial violence, child labour problems, atrocities against women, environmental degradation etc. which were brought to public notice through mass media, voluntary organizations and judicial activism. A National Human Rights Commission (NHRC) has been constituted by the Central Government which has created confidence among Indian citizens. The functions of NHRC has been both investigative and permitive and it acts as a promoter of a culture of human rights in the country. NHRC promotes and cooperates with voluntary organisations active in the area of human rights. It also conducts carefully designed oriented training programmes for police, armed forces and para-military forces to apprise them of human rights.

• 5.6. VALUE EDUCATION

The word *value education* refers to the means of developing the appropriate sensibilities, *viz.*, moral, spiritual, cultural and the ability to make proper judgement and internalise them in one's life. It is an education for becoming a responsible citizen of the country. Value education gives informations to :

(i) live ones life in a decent way

(ii) find happiness

(iii) make others happy

(iv) behave and communicate with other persons

(v) grow and get success in life

Value education has different phases, *i.e.*, value orientation, value awareness, value selection, value appraisal, value commitment and value action. The main objective of value education is to create and develop awareness about the values, their significance and role. The student should critically analyse the importance of value education because it gives him the idea to choose things which really appeal to him.

Much has already been talked about environmental education. It can be made value based in incorporating following steps :

(i) Preparation of good text books which can inculcate in the minds of the readers the basic human value '*man in nature*' rather than '*nature for man*'.

(ii) Social values like love, tolerance, justice and compassion should be the basic things during the teaching.

(iii) Cultural and religious values should be critically studied and taught.

(iv) Global values that human civilisation is a part of the planet should be mentioned.

• 5.7. WOMEN AND CHILD WELFARE

The woman has now become an important integral part of the modern society. The status of women has been enhanced in the present day world by the following strategies :

(i) Providing education

(ii) Imparting vocational training.

(iii) Generating awareness.

(iv) Improving and giving equal employment opportunities.

A National Commission for Women (NCW) has been set up by the Central Government, whose main functions are :

(i) To examine constitutional and legal rights for women.

(ii) To review and give suggestions regarding the improvement of existing legislations.

(iii) To sensitise the enforcement and administrative machinery to women's causes.

The gender inequalities are slowly being removed and this issue is attracting serious attention of the government and other voluntary organizations.

The Indian constitution prohibits the child labour. Stringent laws have been framed but no follow up action is taken to curb the menace of child labour. The provision of the legislation is implemented more in letter than in spirit. Integrated child welfare schemes, like Indira Mahila Yojna, Adolescent Girl's Scheme and National Nutrition Policy are some of the schemes to promote nutritional, health, literacy, education, recreational and skill development needs of women and children in the country. According to World Summit for Children (1990), a plan of action has to be devised and implemented by different countries of the globe to achieve the goals for development and protection of both women and child as far as their welfare is concerned. An awareness has arisen in the country to strive for women and child welfare.

• 5.8. ROLE OF INFORMATION TECHNOLOGY IN ENVIRONMENT AND HUMAN HEALTH

The scientific society around the world is currently richer than before with data and knowledge concerning the global environment. However, the decision and policy makers as well as the general public, in particular in the developing world have little or no access to this information in an easily understandable way. Till today, the citizens including the politicians have not been able to feel any impact from the worldwide phenomenon of ozone layer depletion, greenhouse effect, climate change or loss of biodiversity. These are all emerging issues where scientists and environmentalists have strongly recommended prompt action than policy makers are able to implement. So, bridging the gap between the policy makers and scientists for the purpose of environmental policy making has become more important in today's perspective.

Global Resource Information Database (GRID) was established in 1985 by UNEP for the purpose of bridging the gap and providing the global society with updated and reliable environment information. The strategic tools for achieving this goal were geographical information technology for the analysis and presentation of information and telecommunications for the dissemination and exchange of information. The need for GRID

was mentioned in the report of World Commission for Environment and Development (1987). Today, the GRID network has grown into a global network of fourteen centres. The importance of information technology tools in environmental management in developing countries, has some inherent issues to be studied and solved. These are :

(i) Bottleneck with respect to data/information : Lack of access to existing data can be a problem. This problem can be solved by information technology.

(ii) Institutional capacity : The receiver's institutional capacity, organization, management and decision systems should be sufficiently well developed to use the IT tools efficiently. The information technology will be quite useless, if not properly used.

(iii) Impact : Internet is the fastest growing medium in the developed world, available by satellites, cable net, telecom network etc. The open network will give us access to the global knowledge and information society. The internet will affect our societies through sharing of information, aquiring of knowledge and new opportunities for work and recreation.

(iv) Infrastructure : Linking information spaces on the internet, opportunities exist to create local, regional and national informations. Linking together citizens, schools/colleges, libraries, newspapers and other information sources will create powerful infrastructures.

Role of Information Technology in Human Health

Through the information technology, one can upgrade all the informations regarding the medical facilities all over the world. This should be used in increasing the scientific knowledge about the environment. The input of data from developing countries is made available to the global warehouse of knowledge and gain access to the best management practices of developed nations in providing scientific and environmental knowledge.

• 5.9. CONCEPT OF ECOLOGICAL BALANCE

[I] Ecology (= Oekologie)

Reiter (1885) and Maeckel (1886) (Greek : *oikos = house ; logos = study)* defined ecolgy as, *'investigations of the total relations of the animal to its inorganic and organic environment'*. It is now defined as, *'the study of reciprocal relationship between living organisms and their environment'*.

Ecology is a synthetic branch of science which is related to other branches like geography, geology, physics, chemistry, limnology, climatology, microbiology and other branches of biology. Ecology is helpful in anti-pollution measures, soil conservation measures and is applied to agriculture, horticulture, silviculture etc.

[II] Environment

Environment means surroundings. It is a complex of several things like light, temperature, soil, water etc. which surround an organism. Each part of the environment which affects the structure or functioning of the plant or its growth is known as a factor of the environment or an *ecological* or *environmental factor*. Various factors are classified into two groups :

1. Physical factors or non-living factors,
2. Biological factors or living factors.

The ecological factors are however, arranged into five categories :

(a) Climatic or aerial factors : These include light, temperature of air, atmosphere, humidity of air, rainfall.

(b) Topographic or physiographic factors : These relate to the form and behaviour of the earth's surface and include altitude, direction of mountains and valleys, steepness and exposure of slopes.

(c) Edaphic or soil factors : These are related to the formation of soil, its physical and chemical properties etc.

(d) Biotic factors : These are the effects of the activities of other plant groups and animals including man.

(e) Fire factors

(1) Climatic or Aerial Factors

Climate means the inclination or angle of sun rays falling on the earth. Climate of any region is determined by meteorological factors such as relative humidity of air, temperature, wind pressures and evaporation rates. The various climatic or aerial factors are light, temperature of air, humidity of air, rainfall (precipitation) and gaseous components of atmosphere including wind.

(a) Light : Light is the visible part of solar radiations falling on earth. All solar radiations do not reach the earth. Ozone, nitrogen, oxygen, clouds, water vapours and dust particles etc. filter out harmful radiations of the earth. Light affects both the plants and animal's lives.

Most of the plants need chlorophyll for their formation, which takes place only in presence of light. Chlorophyll production usually increases with decreasing light intensity. In the conifers, ferns and many algae, green colour also develops in the absence of light. In all cases, however, light is necessary for the functioning of chlorophyll in food synthesis. Light affects plants in many ways, by its intensity and quality and by its duration. Light is an important factor in transpiration which keeps down the temperature of plants.

Light has also an effect on animals, by affecting their several types of activities like metabolism, reproduction, development, growth, pigmentation, locomotion, photoperiodism etc.

(b) Temperature : Temperature of a place is determined by its distance from the equator, *i.e.*, its latitude. It regulates all chemical processes of plant metabolism and many physical processes. The metabolic processes occur at a certain *minimum temperature*, increases with rise in temperture till they reach a maximum at a temperature called *optimum temperature*. Further rise in temperature is accompanied by a fall in the metabolic activity till it stops at a temperature known as *maximum temperautre.*

The vegetation of the world can be classified into ***hekistotherms*** (plants of very cold habitat), ***microtherms*** (plants of cold habitat), ***mesotherms*** (plants of habitat which is neither very cold nor very hot) and ***megatherms*** (plants of warm habitat).

Both, extremely low and high temperatures produce ill effects on the growth of plants. Low temperature causes cold injuries as desiccation, chilling injury and freezing injury. Extremely high temperature can cause stunting and final death of plants, due to adverse effects on several physiological processes like respiration, transpiration, protein metabolism In animals, temperature affects growth as well as development. Temperature also affects the reproduction of plants, sex ratio etc.

(c) Atmospheric humidity : Humidity of air has a significant influence on plant life than light and temperature, as it affects the water relation of the plants. It affects the rate of transpiration. Atmospheric moisture in the form of water vapours is called ***humidity***. The humidity of air is expressed in terms of ***relative humidity***, which is defined as,

"The amount of moisture in air as percentage of the amount which the air can hold at saturation point at that temperature."

Humidity is influenced by temperature, altitude, wind, exposure, solar radiation, cover and water status of soil. Relative humidity determines the dryness of air and so the rate of transpiration. The lower the relative humidity, the greater is the rate of transpiration. Plants growing in areas of high relative himidity show luxuriant growth. Dry areas develop sparse and dwarf vegetation. Many orchids, lichens, mosses and desert plants absorb water directly from the air, if the relative humidity is 85 percent or more. High humidity decreases both irradiation and transpiration, while low humidity increases both. High humidity increases the incidence of several viral, bacterial and fungal diseases. It produces *corky parenchyma (russeting)* in pear and apple.

(d) Wind : Wind has both a direct and indirect effect on plant life mainly on flat plains, along sea coasts and at high altitudes in mountains. Wind is directly involved in

transpiration in causing several types of mechanical damage and in dissemination of fruits, seeds and pollens.

A high velocity wind causes bending and flattening of crop plants against the ground—a process called *lodging*. Wind may also cause breakage of branches and tender tree top and can also uproot plants. On ridges, the trees are often found to lie flattened or in an inclined position. Icy or sandy winds cause ***abrasive action***. It removes buds and tender bark of the plants. The injured and exposed bark becomes desiccated and gets killed. Due to constant blowing of wind at sea-shore, on the edge of a forest and above the alpine or arctic timber line, the plants get dwarfed. The branches beyond a certain height get broken or dried off. Grasses, herbs etc. grow in such conditions. Wherever the soil cover is thinned or loosened, wind blows away the soil particles. The plants whose roots are exposed get killed. The eroded soil is deposited at vegetation at other places. The covered plants are suffocated to death. However, wind helps in both pollination and dispersal of fruits and seeds of some plants.

The physiological effects of wind are :

(i) Desiccation : Wind increases evaporation from soil and transpiration from plant surfaces. It also causes bending of leaves.

(ii) Salt spray : At sea coast, the wind blows away water droplets from the sea surface. These droplets being rich in salts are called *salt spray*. When they get deposited on the surface of plants, the salts remain on it after evaporation of water. This causes exosmosis as well as blocking of stomata of plants.

(e) Rainfall (Precipitation) : The main forms of precipitation are rainfall, hail, snow and dew. Rainfall is the most important as most plants absorb water from the soil. The vegetation of any region is determined by the amount and seasonal distribution of rainfall. Low amount of rainfall produces aridity and desert conditions. Heavy rainfall, confined to a few months in a year, results in deciduous forests. Grasslands are found in regions of high summer rainfall and low winter rainfall. Regions with very low rainfall both in winter and summer correspond with deserts.

Snow (moisture as solid state) is injurious to plants. Exchange of gases is prevented when plants get completely covered with snow flakes. Non-availability of oxygen and accumulation of by-products of anaerobiosis are harmful. The weight of snow causes the breakage of branches and tender tops. The effect is severe, if snowfall is followed by wind. Hail (balls or lumps of ice) flattens crops and denudes trees of their foliage, fruits etc.

(2) Topographic Or Physiographic Factors

The unevenness or irregular factors of the earth's surface are called *topographic factors*. These are of five types—altitudes, steepness of slope, exposure, direction of mountain chains and valleys.

(a) Altitude : With the rise in the altitude, the temperature decreases, rainfall increases and wind velocity increases. There is higher insolation when the sky is not overcast. Mountains show different vegetation zones at different heights.

(b) Steepness of slope : The degree of slope and its smoothness determine the degree of runoff or surplus rain water and hydration of the soil. The steeper the slope, the higher shall be the velocity of the runoff. This cuts the superficial layers of the soil. Due to this, the slopes become denuded of soil. The rapidly moving water does not find time to percolate in the slopy soil. Despite the rain, the slopes are dry and bear only *xerophytic plants*.

(c) Direction of mountain chains : Mountains intercept the moisture laden winds coming from the sea. Such an interception causes heavy rainfall near the foot hills. Most mountain formations of India help in intercepting monsoon winds and cause widespread rain. The Himalayas direct the monsoon to spread rain throughout Northen India. The Aravali range of mountains lie parallal to the direction of the monsoon winds originating from the Arabian Sea. They are thus unable to intercept the winds to a great extent. So, Rajasthan does not get much rains.

(d) Exposure : The sunward slope gets sun's rays nearly at right angles during the mid-day and the non-sun facing slope gets slanting sun's rays. Thus, irradiation is greater on the sun facing slope than on the non-sun facing slope.

A sun facing slope exposed to moist wind has luxuriant mesophyllous vegetation, while the same slope with dry wind has dry xerophytic vegetation. Non-sun facing slope with equal moisture has thicker vegetation.

(e) Valleys : Valleys have luxuriant vegetation as compared to nearby mountains. In the hills, the ground water is placed very deep, while in valleys, it lies very near to the soil surface. Valleys have also finest soils and receive more rainfall than other locations situated at the same height. In areas of high wind velocity, valleys are sheltered places and have denser vegetation as compared to open places. Valleys present behind high mountains receive less rainfall.

(3) Edaphic or Soil Factors

Soil is the medium in which the plants grow. It is defined as, *"the weathered surface of the earth's crust which is mixed with organic matter and in which plants grow."* Soil is formed by the weathering of rocks [Fig. (1)]. The factors relating the structure and composition of the soil are known as **edaphic factors.** These are described as follows :

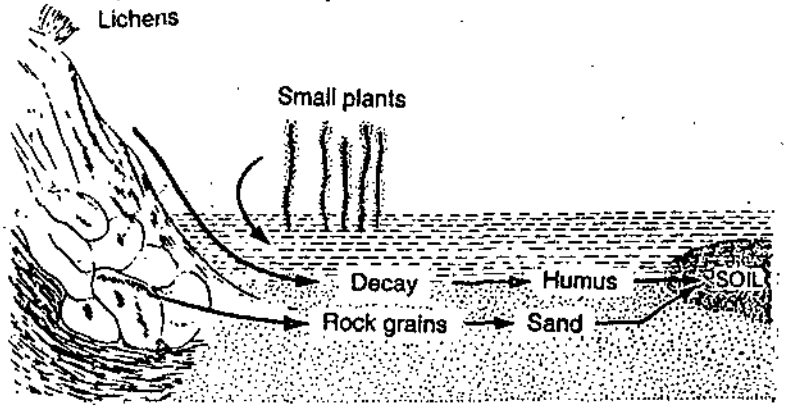


Fig. 1. Formation of soil.

(i) Mineral matter : This part of the soil occurs in the form of particles. These particles are irregular in size and shape and so they cannot be packed tightly. They enclose

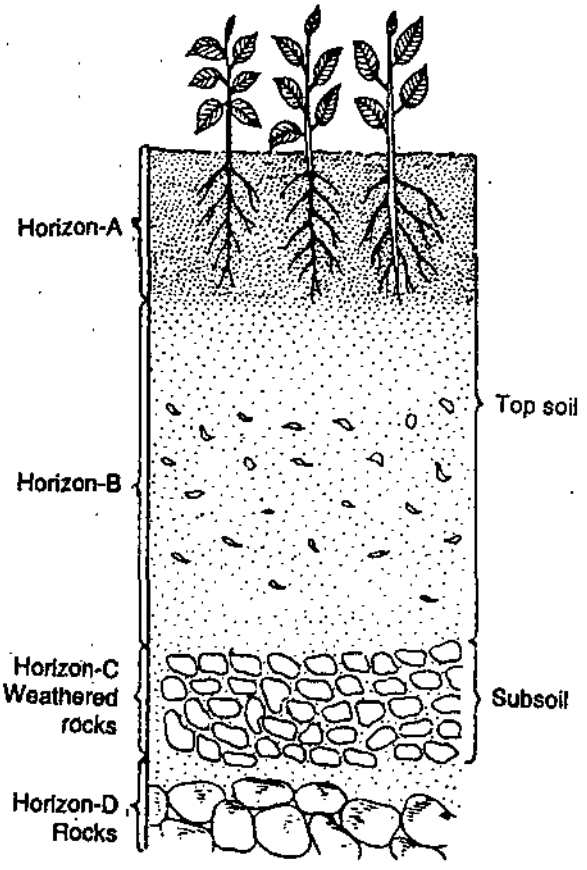


Fig. 2. Diagrammatic representation of a soil profile.

numerous spaces for the circulation of water and air. The weight of mineral matter provides for achorage of the plants.

Depending upon the size, the mineral particles have been termed as coarse gravel (above 5 mm), fine gravel (2–5 mm), coarse sand (0.2–2.0 mm), fine sand (002–02 mm), silt (0.002–0.02 mm) and clay (less than 0002 mm), sand and gravel give physical support to the plants, while silt and clay determine the water holding capacity and nutrient availability of the soil.

The structure of soil can be understood by cutting a vertical section of the soil. In it, we see a number of layers super-imposed one above the other and all of them are known as **soil profile** [fig. (2)]. It consists of the following layers :

(a) A-horizon : The uppermost layer is called A-horizon. This is the top soil in which crops grow. It is rich in humus. The A-horizon is covered by a surface layer consisting of fallen leaves and dry twigs, in areas of thick vegetation.

(b) B-horizon : It contains iron and aluminium compounds in addition to humus and clay. It is brown in colour and lighter than the top soil. It is more compactly packed than top soil. It serves as a reservoir of water. The rain water accumulates in sub-soil and rises to the top soil by capillary action.

(c) C-horizon : Under the sub-soil is the parent rock material into which the deeper roots of plants grow.

(d) D-horizon : It is the lowest region and consists of unweathered rocks.

An average garden soil has the following composition :

Mineral matter	:	40 percent by volume
Organic matter	:	10 percent by volume
Water	:	25 percent by volume
Air	:	25 percent by volume

Based on the relative proportion of rock particles of different sizes, the texture of the soil is determined and affects the plants which grow in it. Soils are classified as gravel, sand, loam, silt and clay. A soil in which the sand, silt and clay particles are present in more or less equal amounts is called **loam** which is most suitable for plant growth. A loam soil predominant in sand particles is called **sandy loam,** and one in which clay particles predominate is called **clay loam.**

(ii) Soil humus : Humus consists of dead organic matter of the soil obtained from the decay of the dead remains of plants, animals etc. and animal excreta etc. It is dark in colour, light in weight. It improves the condition of the soil, making it porous by separating the clay particles. This increases aeration and percolation of water and its absorption by the soil. In such a soil, roots penetrate readily and bacterial activity increases. It is a source of good *vegetation in regions of moderate rainfall.*

In forest, the forest floor is covered by dead leaves and twigs which are slightly or not at all decomposed. This is called **litter.** Beneath it, is a layer of partially decomposed organic matter called **duff.** Still deeper, the decomposition is appreciable and the layer is called **leaf mould.**

(iii) Soil organisms : The important soil organisms are fungi, algae, bacteria, roots, protozoa, rotifers, insects, earthworms etc. The large number of micro-organisms present in the soil bring about the decomposition of dead organic matter of animals and plants to simpler substances, to be used by the plants. Some bacteria, algae increase soil fertility by fixing the atmospheric nitrogen. The earthworms cultivate the soil and bring deep soil to the top soil. They consume large amounts of soil, digesting nutritious matter from it as it passes out of their body. The burrows of the earthworms improve the aeration and drainage of the soil. Some bacteria and fungi etc. cause injury to plants.

(iv) Soil temperature : Functional activity of the root decreases as the soil temperature falls below a certain optimum, whereby water absorption stops and the plant wilts even though the soil is saturated with moisture. Low soil temperature induces dwarf size plants. Cold soils favour prostate shoots and rosette like growth, whereas warm soil brings forth slender and tall plants. It also affects the activities of micro-organisms.

(v) Soil water : For its description, see 'soil pollution'.

(vi) Soil air : See 'soil pollution'.

(vii) Soil cover : Soil cover may be living or non-living. It protects the soil from loss of water and rapid temperature changes.

(viii) Soil reaction : It also affects the plants. The reaction of the soil is due to soil solutions. The reaction is acidic or alkaline, according as the H^+ ions or OH^- ions are in greater concentration. It is expressed in terms of pH. If the pH is zero, less than 7 or greater than 7, then the soil is neutral, acidic or alkaline, respectively. Neutral or slightly acidic soils are best for the growth of majority of plants. Most of the crop plants and vegetables are injured when grown on acid soils. Wheat, barley, tobacco, sugar beet, cabbage, carrot, lettuce, spinach, onion, chillies etc. fall in this category. Certain crops like rice, rye, maize, cotton, beans, groundnut, soyabean etc. can withstand fairly acidic soils. Soil acidity, if it exceeds the safety limit must be corrected by adding fertilizers like calcium nitrate, calcium cyanamide, basic slag etc. They leave lime residues in the soil.

(4) Biotic Factors

The effects of the activities of living organisms constitute biotic factors. These include the interaction amongst plants, like trees, shrubs, mosses etc. which grow together in community, between the plants and local animals and between the plants and soil micro-organisms. Amongst the animals, man also modifies the vegetation. This is clear in agriculture and forestry where many of his activities end in modifying vegetation and the environmental factors. Biotic factors can be classified and studied under three heads :

(a) Effect of plants (b) Effect of animals (c) Effect of men

In soil there is a competition among members of the same species and members of different species. It is more intense in the former. As a result of competition, the height, size, vigour of the plant, branching, number of flowers are reduced.

Another important biotic factor is due to the grazing animals. Grazing by domestic animals affects the grazed plants thus causing injury. Animals cause damage to plant life, which feed on tender shoot of many forest trees. Some animals like bisons, elephants cause damage by feeding upon the shoots or uprooting seedlings. Insects bring about pollination. Grazing animals also contribute to the dispersal of fruits and seeds.

Cutting, felling and replanting of forest trees are cases of man's reaction on vegetation. Indiscriminate or selective felling of useful trees has changed the pattern of our forests.

(5) Fire Factor

Forest fire caused by man's activity are responsible for partial or complete destruction of vegetation. The shallow rooted plants are completely destroyed, while the deep rooted plants are only temporarily affected. The latter, however, sprout up following the first rains after the fire. Forests are sometimes burnt by man to clear the ground for agricultural and pasture purposes, for building roads or habitations etc. or for replacing old species by new more valuable species.

There are three kinds of forest fires, *viz.*,

(a) Ground fire : It is flameless and occurs in areas having thick accumulation of organic matter.

(b) Surface fire : It often sweeps on the ground surface rapidly, destroying the ground flora and scorching the basal parts of trees. Soil humus is burnt out and soil becomes unfit for plant life.

(c) Crown fire : Such fires have tall flames, spread rapidly in the direction of the wind. It burns the whole trees and large forest areas and affects the tree tops. It is common in dense forests.

• 5.10. MEASURES FOR ECOLOGICAL BALANCE

[I] Conservation of Soil

Soil conservation (Latin : *con* = together : *servare* = guard) means the keeping of the soil in place, maintenance of soil fertility and the efficient use of land with a view to

establishing a stable, scientific agriculture. In India, soil conservation is supervised by Central Soil Conservation Board which has centres at Dehradun, Agra, Ootacamund, Bellary, Vasad, Kota, Jodhpur, Chandigarh. Different methods used for soil conservation are mentioned below.

1. Soil fertility : On infertile soil, plants do not grow well. Such soil is exposed to wind and water erosion. Fertility of a soil depends on its humus content and mineral content. Humus supplies plant nutrients to the crops and absorbs water. It reduces the rate and amount of runoff and thus helps in the prevention of soil erosion. Soil fertility is maintained by the addition of manures and fertilizers. They improve both aeration and hydration. Presence of manure decreases run off.

2. Crop rotation : It is the practice of growing different crop plants in successive years on the same area of land. In crop rotation, the sowing of leguminous crops such as groundnuts, beans, grams, pulses and alfalfa as part of the rotation programme restores the much needed nitrogen compounds to the soil. Crop rotation prevents soil depletion and especially when used with farm manures and fertilizers, it is valuable in soil conservation.

3. Fallowing : It is an old method to improve soil fertility and prevents soil erosion. After harvesting of a crop, the land is left untilled for one or more seasons. During the period of fallowing, herbs and grasses grow on the soil. Animals graze on the land. Their excreta and organic matter of the previous crop plus the new plant growth help stimulate the humus growth and mineral recovery. This method is, however, not used now, because of the pressure on the land.

4. Mulching : The soil is allowed to remain untilled. It is covered with litter, leaves, crop residue, grasses, straws etc. Mulching retains soil moisture, increases soil infiltration, decreases the runoff, reduces the incidence of weeds, stimulates growth of soil flora and fauna and increases humification. This covered soil does not come in direct contact with agencies of soil erosion.

5. Contour farming : It is practised on hill slopes. The land is ploughed at right angle to the direction of the slope. It produces circular furrows and ridges around the slopes. The ridges check the flow of rain water straight down the hills, so that there is more time for its absorption. The growth of plants in circular rows gives rigidity to the ridges and prevents soil erosion. Contour farming reduces runoff and soil erosion. It saves water for the crop and increases their yield.

6. Strip cropping : If entire slopes are ploughed and planted as one unit, the rain water flows down the entire slope and collects in low places. Longer the slope, faster will be the runoff. If the long slopes are broken up into a number of strips laid out across the slope, the crop rows are on level. Strips of dense growing and soil covering crops such as cereals, grasses, alfalfa etc. are alternated with clean tilled crops. This arrangement checks the momentum of runoff, filters out the soil carried from the tilled areas and increases the absorption of rain water.

7. Ley farming : Grasses are sown either in rotation or along with agricultural crops like jowar etc. Grasses prevent soil erosion and improve soil permeability.

8. Controlled grazing : Sheep and cattle eat the green parts of plants. The surface soil trampled under the hoofs of animals becomes compact so that rain water no longer soaks readily. Chopping off the tops of plants prevents them from reseeding themselves. However, the excessive grazing should be avoided.

9. Development of grasslands : Grasslands are very effective in holding the soil and preventing erosion. They should be developed in vacant lands in public offices, educational institutions, in hospitals, on wastelands near towns and villages. Besides providing food for cattles etc. Grasses help to absorb rain water and increase the fertility and stability of soil.

10. Terraces : Dividing a slope into a number of small flat fields is called *terracing*. Terraces slow down the velocity of the runoff and prevent soil erosion. It is, however, a costly process.

11. Afforestation and reforestation : Afforestation is the formation of forests where no forests existed previously because of climatological, geological or political reasons.

Reforestation is the replantation of forests which have already been destroyed by overgrazing, felling or fire.

Destruction of forests or deforestation in hilly areas occur due to decreased frequency of rainfall, increased and quicker melting of snow, occurrence of floods etc. Afforestation of hills is useful because it prevents soil erosion, as

(a) Soil becomes more porous and permeable due to *in situ* of roots.
(b) Plant cover protects the soil from the direct beating of rain drops.
(c) Roots hold the soil firmly.
(d) Water holding capacity of soil surface increases due to accumulation of organic matter.
(e) Melting of snow is slowed down and even delayed if the hills have dense growth of bushes and trees.
(f) The frequency of rainfall increases.
(g) Catchment areas are slowly filled which reduces the chances of floods.

Forests are a great national wealth. They give us fuel wood, timber for construction and wood pulp for paper, gums, resins, turpentine and allied substances, medicinal substances like quinine and myrobalans, food and shelter for animals and men. Forest fires have destroyed millions of acres of valuable forests. The loss of forests has resulted in the loss of crops, wild animals and valuable soil etc.

Afforestation and reforestation have been tried in the past. Emperor Ashoka got a number of trees planted along the highways. Government of India recognised the seriousness of the problems arising due to deforestation and introduced a tree *plantation movement*, called **van mahotsava**, in 1950. It is celebrated for a week each in February and July, every year. In these weeks, new trees are planted throughout the country. Plantation of trees in the plains reduces the pressure on the hill forests for obtaining useful things like fuel, timber etc. It also reduces the incidence of dust and electric storms. Free growth is also helpful in reducing the acidity and alkalinity of soils.

Baramulla and Sankaracharya Hills of Kashmir have been successfully protected through mixed planting of conifers, *e.g., pinus, cedrus* etc. and broad leaved species like *aesculus, juglans regia* etc. In the areas to be afforested, the water and soil conditions are made favourable. Ditches are made for retaining rain water. Plants should be so chosen so as to suit the climate of the area. The trees are planted at a distance of 1 metre to give quick protection to the soil and to save them against mortality. As the trees become taller, the slow growing plants are removed. Water logged areas, *e.g.*, of Punjab need quick growing plants like *eucalyptus* which will help in pushing down the level of sub-soil water. The area currently under forest is nearly 6,00,000 square kilometres.

12. Gully and ravine control : The gullies are filled up with brush and stone dams. Wooden logs or stones are kept at the bottom of the gully or ravine. They are fixed at their places by knots of wire. Soil erosion from the side of gullies or ravines can be checked by the growth of grasses or other vegetation.

13. Dam building : Dams built in the head waters of major streams are quite effective in checking soil erosion. Water which flows down the hills in torrents during rainy season cause floods and severe soil erosion. Dams are an insurance against flood loss. They also collect surplus water and store it to be used for irrigation and other purposes.

14. Bank protection : Stones are used to keep water flow in a specified area. Bends are made straight as far as possible or are strengthened with concrete. The banks are stabilised by the use of several types of grasses like *Phalkris arundinacea, Arundo donax, Saccharum species, Legumes, e.g., medicago,* shrubs and trees like *Negundo populus, Morus* etc.

15. Control wind erosion : The method used for controlling wind erosion are covering of soil with vegetation, keeping the soil rough rather than smooth, strip cropping, ploughing across the slopes for holding water and planting rows of trees across the prevailing winds as wind breaks. This helps in blowing away of the valuable soil and the drifting of sand onto the crops, roads and farmsteads.

[II] Conservation of Water

Water is important for all living animals, humans and plant kingdom. We cannot live without water. The sources of water, are rainfall, rivers, pond, streams, underground water, sea etc. The water cycle is existent in nature, whose mention has already been made. If the water cycle is disturbed in any way, then water crisis occurs. The water from sea, rivers etc. is evaporated due to heat of the sun. In the upper atmosphere, at a certain temperature and pressure, the water vapours form clouds. When the temperature is very low, these clouds condense and fall as rain drops on earth. The snow on the mountains melt during summer and through rivers come down to the sea, which is again evaporated and condensed as rain. This water cycle does not remain the same throughout. Sometimes it rains more and sometimes it rains less. This is the reason, why water should be conserved to be used in needy times. The measure for conservation of water are :

1. Building of dams : Small dams should be constructed, so that water can be stored in them. It can also be used for irrigation and other purposes.

2. Formation of ponds etc : Ponds should be constructed to store rain water.

3. Afforestation : Where there are more trees and plants, we get more rains. So, efforts be made to plant trees and plants in selected areas. Due to this, we can get rains in dry areas.

4. Water should not be wasted and be used judiciously. Taps should not remain open. Water should be avoided from being polluted.

[III] Conservation of Plant Life

Conservation of plants and trees means the conservation of forests. We should not cut or fell trees indiscriminately, as they give us fuel wood, timber, wood pulp for paper, resins, turpentine and allied substances, medicinal substances etc.

Efforts be made to preserve the plant life and our government has taken steps in this direction. Felling of trees has been banned and made a cognizable offence punishable under law. More nurseries should be available from where even matured trees could be taken out for development of forests. The old natured trees should be replaced by new. The seeds must be well protected. In district parts and other big areas, extensive afforestation programmes be taken up. The building of roads, where trees exist should be banned.

[IV] Conservation of Animal Life

Animals mean domesticated or non-domesticated animals found in nature. Conservation of wild life is of great importance due to its ecological value, game value, commercial value, scientific value, asthetic value and ethical value. The steps commonly used to conserve wild life are as follows :

1. Establishment of parks, reserves and sanctuaries : The establishment of National Parks, Sanctuaries, Zoological Gardens, Wildlife Reserves help us to conserve species in their wild form and to provide scientific and educational opportunities.

2. Habitat management : In this, we include the ecological study of the habits and habitats of wild life species, protection, preservation and improvement of habitats etc.

3. Breeding in captivity : Captive breeding also helps us to save the wild life from exitinction.

4. Reintroduction : Several animal species which were almost extinct were allowed to reproduce in places similar to the original places. These species were then transferred to several parks and sanctuaries and areas of their original habitats.

5. Mass education : People should be educated about the conservation programmes. For this, tours, seminars, nature clubs be introduced. Wild life week should be celebrated very year, wild life books and journals be published.

6. Lagal punishment : All countries have promulgated law for the protection and conservation of wild life. In 1972, 'The Wild Life (Protection) Act, 1972' was enacted by Indian Government. It prohibits killing, capturing and hunting of wild life, without prior permission and poaching has become punishable under the law. However, the law should be amended further to give heavier and deterrent punishment to law breakers and poachers.

SUMMARY

- The population growth is governed by birth rate, death rate, immigration, emigration, change in environmental factors, biotic factors, abiotic factors etc.
- Zero population growth is the stage when the birth rate equals the mortality rate.
- AIDS can be diagnosed by Elisa test or Western Blot test.
- Ecology is the investigation of the total relations of the animal to its organic and inorganic environment or study of reciprocal relationship between living organisms and their environment.
- Humus is the dead organic matter of the soil obtained from the decay of the dead remains of plants, animals etc. and animal excreta etc. it is dark in colour, light in weight.
- The measures for ecological balance are conservation of soil, water, plant life and animal life etc.

Student Acticity

1. Write the formula for annual average growth rate.

2. Write five lines about family welfare programmes.

3. What is HIV?

4. How is animal life conserved?

5. Define afforestation and what is its use?

TEST YOURSELF

Answer the following questions :

1. Explain population growth. How does it vary among nations?
2. Explain the objectives and usefulness of family welfare programmes.
3. Write a short note on 'population explosion'.
4. Discuss the environment and its effects on human health.

5. Discuss population explosion in Indian context. What should be the objectives of a sound population policy ?
6. Write a note on women and child welfare.
7. Write short notes on the following :
   (i) Human rights (ii) Value education
   (iii) Population explosion (iv) AIDS
8. What is AIDS ? What are the sources and mode of transmission of HIV infection ?
9. What is 'Value Education'? Discuss the concept of value education with the help of suitable examples.
10. What do you understand by the term'Human Rights'. List the important articles of the 'Declaration of Human Right, 1948' adopted and proclaimed by United Nations.
11. Define the terms : ecology, enviromnent, ecolgical factor.
12. Describe the climatic factors on the ecological balance.
13. What are climatic factors ? Explain the effect of any two of them on the form, structure and distribution of plants.
14. What are topographic factors ? Explain their effect on the growth and distribution of plants.
15. Discuss the effects of man and animal on the vegetation of a place.
16. Discuss the effect of biotic factors on plant life.
17. What is the effect of fires on the vegetation of a place?
18. What is ecological balance ? Discuss.
19. What are soil and soil profile ? Discuss each in detail.
20. What are edaphic factors ? Give a brief account of these factors.
21. "Our forests are the boon for us". Justify this statement.
22. What is humus ? How it is useful?
23. What is soil cover and what is its importance?
24. Write short notes on the following :
   (a) Soil conservation (b) Water conservation
   (c) Conservation of plant life (d) Conservation of wild life
   (e) Environmental management
25. Differentiate between afforestation and reforestation. Give their uses.
26. What is van mahotsava ? Give its benefits.
27. What steps can be taken to protect soil from soil erosion ?
28. What is environmental management ? Explain the concept and measures of ecological balance.
29. Write an essay on environmental management.
30. Describe the importance of forests and explain the factors of depletion of forests.
31. Describe the importance of forests for the conservation of environment.
32. What are the major factors responsible for forest depletion in India ? Explain the importance of its conservation.
33. **Fill in the blanks :**
   (a) We get rains in dry areas due to ..... .
   (b) When birth rate = mortality rate, it is called ..... population growth.
   (c) ..... test is used for diagnosing HIV.

ANSWERS

33. (a) afforestation (b) zero (c) elisa.

❑❑❑

UNIT

6

PHYTOGEOGRAPHIC REGIONS

STRUCTURE

LEARNING OBJECTIVES

After studying this chapter, you will learn about the main plant communities of the world as well as soils, climate and vegetation of India.

Phytogeography is the study of origin, environmental relationships and distribution of plants both in time and space. Phytogeography is classified into two types :

(i) Descriptive or static phytogeography : It deals with the description of flora and vegetation in different parts of the world.

(ii) Interpretive or dynamic phytogeography : It deals with the interpretation of causes of plants distribution.

6.1. MAJOR PLANT COMMUNITIES OF THE WORLD

Major plant communities are divided mainly on the basis of the kinds of habitat and environmental conditions.

[I] Aquatic Communities

(1) Fresh water communities : They occur in fresh water habitats, like lake, pond, swamp, river, spring etc. The main components are seed plants, phytoplanktons etc.

(2) Marine communities : They occur in marine waters of seas and oceans. The main components of this type are phytoplanktonic diatoms, microflagellates and profuse growth of brown, green and red algae which form *seaweeds.*

(3) Estuarine communities : These are found in transition zone between the fresh water and marine habitats, under strong effects of tidal actions. Seaweeds, sea grasses, marsh grasses and some phytoplanktons are examples of this type.

[II] Terrestrial Communities (Biomes)

These are recognised as larger units—the biomes. The major biomes of the world are as follows :

(1) Tundra : These biomes cover large areas of the arctic zone. The vegetation consists of dwarf, treeless community— **the tundra.** The common plants are mosses, sedges, grasses, lichens etc.

(2) Northern coniferous forest biomes : *They occur as thick belt of evergreen* forests across both North America and Eurasia. The biome is evergreen trees, *viz.,* pines, firs etc.

(3) Moist temperate coniferous forest biomes : They occur along the west coast of North America from Central California to Alaska. These are dominated by conifers.

(4) Temperate deciduous forest biomes : In this area, beech, maple, oak, chestnut etc. are the prominent trees. Herbs and shrubs are well developed. The areas are eastern North America, all of Europe and parts of Australia and Japan.

(5) Sub-tropical forest biomes : The areas include the warm temperate marine climate. The difference in temperatures between summer and winter is very less. It gives rise to broad leaved evergreen forests, the plants being *quercus virginiana, magnolias, bursera, sabal palmetto* etc.

(6) Temperate grasslands biomes : These are areas where the rainfall is very low (10" — 30"). It gives rise to grasslands, where tall grasses, mid grasses and short grasses are the main species.

(7) Tropical savannah biomes : These are found in warm regions where the rainfall is 40"—60" with prolonged dry season. Trees are less in number. Adansonia, euphorbias, palms, grasses like *panicum, imperata* are major species.

(8) Desert biomes : These are areas where the rainfall is less than 10". The life form of plants found in these areas are annuals, succulents and desert shrubs, mosses, algae and lichens.

(9) Chaparral biomes : These are areas found in mild temperate zones with abundant winter rainfall but dry summers. The vegetation consists of trees or shrubs with thick hard evergreen leaves.

(10) Juniper biomes : These areas have high moisture content, rainfall is 10"—20". *Pinus edulis*, several species of *juniperus* etc. are found.

(11) Tropical rain forest biomes : They are low altitude zones near the equator, with a rainfall of 80"—90". Climbers, especially *woody lianas* and *epiphytes, vines, shrubs*, etc. are the plants grown.

(12) Tropical deciduous forest biomes : These are areas where moisture content is intermediate between rain forest on one hand and desert and savannah on the other. The vegetation is of thorn forests class.

• 6.2. SOILS OF INDIA

There are 24 types of soils in India and these have been grouped into six categories on the basis of their nature and composition. These are shown in figure (1).

(1) Alluvial soils : These are transported soils formed through siltation of rivers and sea. They have very good agricultural productivity. The soil is generally alkaline, sandy loamy in texture, light coloured to brownish. It is found in Bihar and U.P. (North), Punjab and Haryana (North West), Meghalaya, Orissa and Bengal (North East).

(2) Red soils : These soils are derived from granite and gneisses. They are porous and friable. It is rich in humus, loam to silt loam in texture and have neutral or acidic character. It contains oxides of iron. It is found in Andhra Pradesh, Tamilnadu, Bihar, Orissa, U.P., some parts of West Bengal.

(3) Black soils : They are locally known as *regurs* or *black cotton* soils. The colour changes from dark brown to deep black. It is obtained partly from hydrated silicates of iron and aluminium and partly from organic matter. These are derived from trap rocks. They are sticky when wet and contract and develop cracks on drying. It is found in Maharashtra, Mysore, M.P., Gujarat, some parts of Andhra Pradesh, Tamilnadu.

(4) Mountain or skeletal soils : These soils lie in Vindhyas and Himalayas (mostly Ladakh). Both rainfall and temperature are poor. So, weathering is slow and soils remain shallow. They are further exposed to erosion. The colour of the soil is pale brown to dark brown and has loamy to sandy loamy texture. Schlerophyllous is the important vegetation of this soil.

(5) Desert soils : These soils are sandy and derived partly from rocks in place and partly blown from coastal areas or Indus Valley. These soils are found in parts of Haryana and Rajasthan and between Indus river and Aravalli mountains. The vegetation is sparse as sand dunes occur at places.

(6) Latosol : It is also known as *laterite soil.* It is found in west of Hyderabad, north of Bangalore, Meghalaya, eastern margins of Chhota Nagpur plateau. It is porous in nature

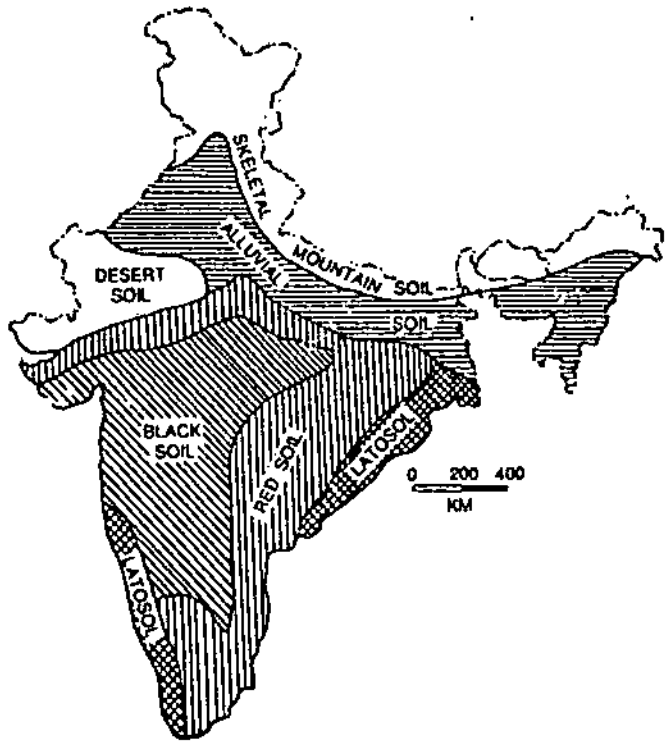


Fig. 1. Different types of soils present in India.

and contains an excess of hydroxides of iron and aluminium. At low elevations, paddy cultivation is done, while at higher elevations, coffee, rubber, tea and cinchona are the major vegetations.

• 6.3. CLIMATE OF INDIA

India is situated entirely to the north of the equator between 8°4′ and 37°6′ N in latitude and between 68°7′—97°25′ E in longitude. Geographically, India lies in the north tropical and sub-tropical belts. Indian climate is essentially monsoonic. Its physiographic features at different places change the climate. Based on this fact, India has four seasons :

(1) **Cold season** from December to February.

(2) **Hot season** from March to May and June in some areas.

(3) **Wet season** from June/July to September.

(4) **Season of retreating monsoon** from October to November.

Meteorologically, it has been divided into two seasons :

(a) **Season of North-East Monsoon :** From December to May with cold period in the first 3 months, and hot period in the last 3 months.

(b) **Season of South-East Monsoon :** The first three to four months is the period of incoming wet winds, while the last two or three months show the period of their retreat.

[I] Climatic Regions

Based on the periodicity and amount of rainfall, India has been divided into the following 4 climatic regions.

(a) **Wet zone :** The rainfall is very heavy, more than 200 cm. It comprises western slopes of Western Ghats, Assam, Arunachal and hills of Meghalaya and Bengal, Mizoram, Tripura, Andamans, Sikkim and terai regions of U.P. and Bihar.

The natural vegetation is evergreen and semi-evergreen forests and paddy is the main crop.

(b) **Intermediate zone :** The rainfall is heavy, between 100 and 200 cm. It comprises parts of W. Bengal, Bihar, Orissa, Eastern Madhya Pradesh, Northern U.P., Himachal Pradesh, J.K., eastern slopes of Western Ghats and Eastern Tamilnadu.

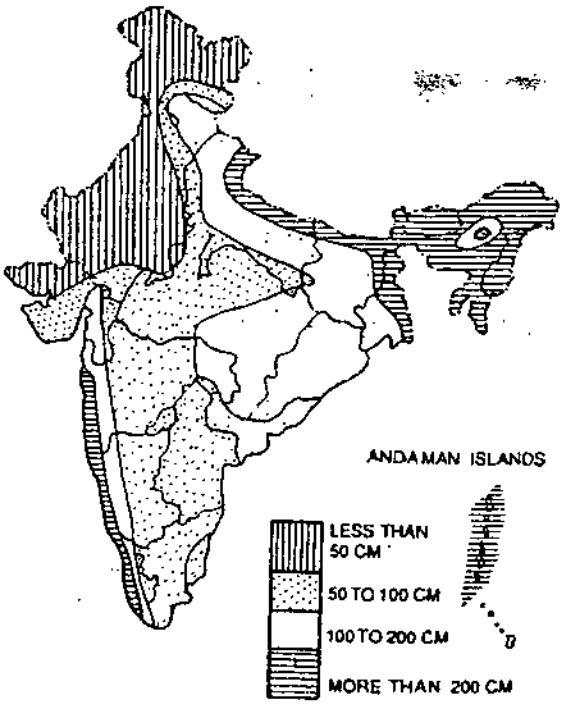


Fig. 2. Diagrammatic representation of a soil profile.

The natural vegetation is deciduous forests.

(c) Dry zone : The rainfall is moderate between 50 and 100 cm. It comprises major parts of Gujarat, South-East Maharashtra, Western A.P., Western U.P., North-West M.P., Punjab, Haryana, Delhi.

The natural vegetation is of dry, deciduous and thorny scrub type forests. Wheat and millets are the main agricultural crops.

(d) Arid zone : The rainfall is less than 50 cm. It comprises Rajasthan, North-West Gujarat, southern parts of Punjab and Haryana.

The natural vegetation is thorny scrub at places and have areas of desert or semi-desert conditions.

• 6.4. VEGETATION OF INDIA

From the point of view of vegetation, India may be conveniently divided into the following nine botanical regions as shown in figure (3).

1. Western Himalayas	2. Eastern Himalayas	3. Gangetic Plains
4. Malabar	5. The Deccan	6. Assam
7. West Indian Deserts	8. Central India	9. Andamans.

[I] Western Himalayas

This consists of the Himalayan range, including the Sub-Himalayan tract from Kumaon to Kashmir. The rainfall varies from 40" to 80" in outer Himalayas (southern region) and in some places it may be 100" or more. In the Inner Himalayas (north-west region), the climate is dry. The vegetation is divided into three regions, *viz.*, submontane or lower zone, temperate or montane zone and alpine zone.

(a) Sub-montane or lower zone : This consists of Himalayas from about 300 m to 1500 m attitude above sea level in the region of Shivaliks and adjacent areas. The forest is dominated by timber trees of *Shorea robusta, Shishum* etc. In grassy areas with less moisture, we have isolated trees of *Acacia catechu and Butea monosperma.* In dry belt in the west we have *Zizyphus, Carissa, Acacia* etc. with thorny succulent euphorbias on slopes. *Pinus roxburghii* (chir) begins to appear around 1000–1500 m. Ground vegetation is poor.

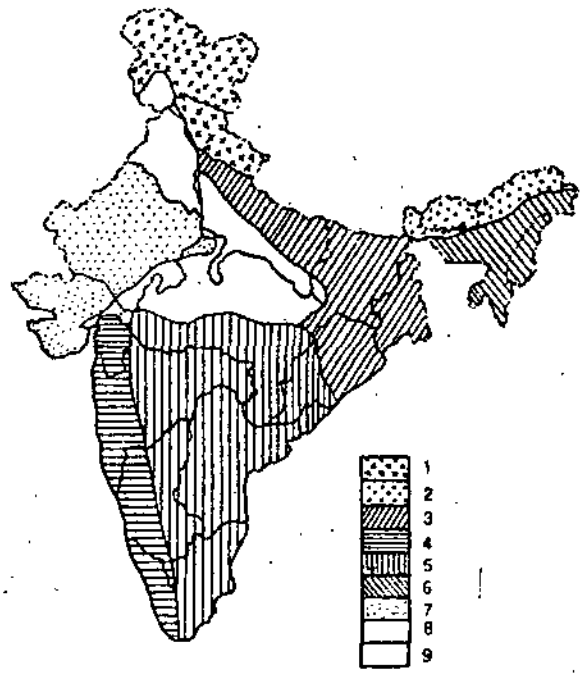


Fig. 3. Map showing different botanical regions of India.

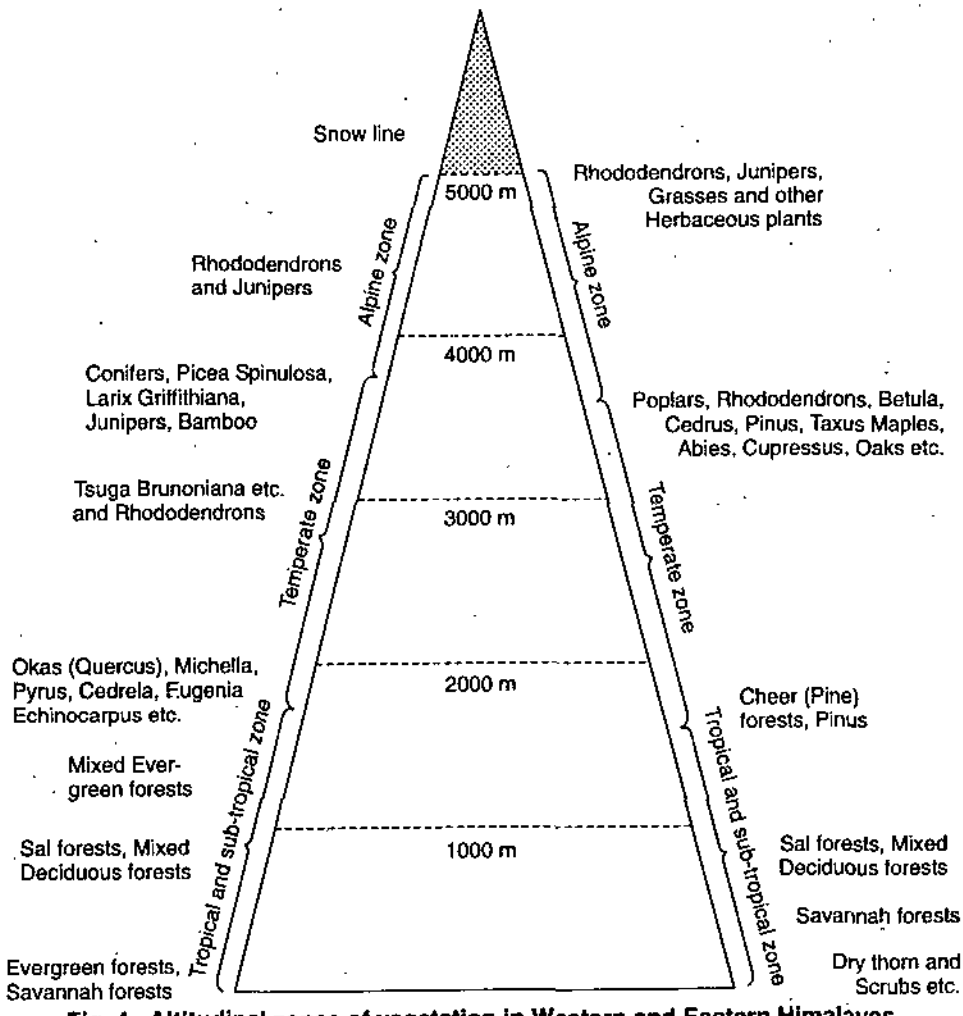


Fig. 4. Altitudinal zones of vegetation in Western and Eastern Himalayas.

(b) Temperate or montane zone : This ranges from 1500 m to 3500 m above sea level. Chir is gradually replaced by *Pinus excelsa*, the blue pine, at about 1600 m. *Cedrus*

deodara (deodar) is quite abundant and form thick forests. *Quercus incana* (oak) also grow abundantly. In the Inner Himalayas in Kashmir, *Betula* (birch), *Salix* (cane) and *Populus* (poplar) are abundant on certain soil types. On higher altitudes, *Aesculus indica* (horse chest nut), *Quercus dilatata*, along with conifers like *Picea morinda*. *Taxus baccata* grow commonly in Kashmir Himalayas. *Rhododendron campanulatum* grow at higher altitudes. In the inner valleys on dry mountains *Pinus gerardiana* also grows. In dry areas of Punjab, wheat and barley are cultivated, while wet Kashmir valley is used for paddy cultivation. Other common plants grown in Kashmir are saffron, apples, peaches, almonds, walnuts, annar etc.

(c) Alpine zone : *It is at about 3500 m (tree line). At this height, the height of plant is* greatly reduced. Low shrubs and grassy meadows are more common. With further increase in altitude, the plant hape becomes more cushion like and small. At about 5000 m (*snow line*) and above, the snow remains perpetually and plant growth is almost nil.

On lower levels of the alpine zone, *Rhododendrons, Betula utilis* and small *Junipers* are found. Above this zone, a large types of harbaceous plants, *e.g.*, *Primula, Potentilla, Geranium, Aster* etc., with beautiful flowers are found. (See figure 4).

[II] Eastern Himalayas

Eastern Himalayas consist of regions of Sikkim and extends to the east upto NEFA. In vegetational zones, it is similar to Western Himalayas. The main differences are due to higher rainfall and warmer conditions in the Eastern Himalayas. The tree and snow lines are higher by about 300 m than the corresponding zones in Western Himalayas. This region is also divided into the same three zones.

(a) Sub-montane zone : This zone is typically tropical with dense forests of *Shorea robusta*, due to warm and humid conditions. *It extends from the plains at the foot of* the hill ranges to about 1800 m altitude. In riverain areas, there are forests of Shishum (*Dalbergia sissoo*) and Khair (*Acacia catechu*). Mixed forests of deciduous trees like *Cedrela toona, Bauhinia, Anthocephalus cadamba, Parviflora, Bamboo* (tall trees) predominate.

(b) Temperate zone : It ranges nearly between 1800 m and 3800 m altitude. It is usually divided into lower temperate and upper temperate zones. The lower zone has several species of oak, *e.g.*, *Quercus lemellosa, Michelia, Cedrela* and *Eugenia* etc. The upper zone which is cooler has such conifers like *Junipers, Cryptomeria, Picia, Abias* and *Tsuga* etc. Some *rhododendrons* are present at higher altitudes.

(c) Alpine zone : It ranges above 3800 m altitude, where the vegetation is devoid of trees. Shrubby growth of *Junipers* and *Rhododendrons* are found in grassy areas.

[III] Gangetic Plains

Gangetic plains extend from the Eastern Punjab to Sunderbans in Bengal and passes through a part of Haryana, Delhi, U.P., a part of Orissa north of the river Mahanadi and Bihar. It is the most fertile region. The main climatic factors, temperature and rainfall are responsible for special types of vegetation. Rainfall varies from 70 cm in western U.P., to more than 150 cm in Bengal. Vegetation is mainly of tropical moist and dry deciduous forest type. In western U.P. at the foot of the Himalayas, *Dalbergia sissoo* and *Acacia nelotica* grow. In southern U.P., there are desert conditions and *Capparis aphylla, Acacia arabica* are some species which grow. In eastern U.P., *Butea monosperma (dhak), Buchanania lanzan (chiraunji), Diospyros melanoxylon (tendu), neem, mango, bargad, lisora, salai, peepal* are some dominant trees grown. Besides these, some weeds and grasses also grow. The Gangetic delta region is very swampy and holophytic vegetation or mangrove vegetation is common.

[IV] Malabar

This region ranges from western coast of India extending from Gujarat in the North to Kanyakumari in the South. This region gets heavy rainfall. The vegetation is of four types, *viz.*,

(a) tropical moist evergreen forests

(b) mixed deciduous forests

(c) sub-tropical or temperate evergreen forests and

(d) mangrove forests.

The tropical wet evergreen forests are very luxuriant and multistoreyed and have tall trees of *Cedrala toona, bamboos* etc. In Nilgiri hills, due to high altitudes sub-tropical and temperate conditions, *Eurya japonica, Michelia nilagirica* are grown.

[V] The Deccan

This region is relatively drier with a rainfall of about 100 cm. It includes Tamilnadu, Karanataka and Andhra Pradesh. It has a central hilly plateau with forests of *Chandan, Tectona grandis, Hardwickia pinnata* etc. In the low eastern dry Coromondal coast, the vegetation is dry evergreen forest.

[VI] Assam

It is the region of heaviest rainfall, with Cherrapunji receiving as much as 400" of annual rainfall. Excessive wetness and high temperature are responsible for the development of thick forests. The hilly tract has made agriculture less possible and as such most of the areas is under dense forests of a variety of broad leaved angiosperms besides some conifers like *Pinus khasiya* and *Pinus insularis.* Sal forests occur in the Garo hills. Bamboo, canes, climbers and evergreen shrubs are found in the Brahamputra and Surma outside the sub-Himalayan regions.

[VII] West Indian Deserts

This region consists of parts of Rajasthan, Kutch, Delhi and parts of Gujarat. The climate is very hot and dry in summer and cold in winter, Rainfall is low, nearly 70 cm or even less. The plants are mostly xerophytic. The ground vegetation is mostly constituted by small *Calotropis, Tribulus terrestris, Suaeda frutieosa* etc. Due to water availability these days, grapes are also being cultivated.

[VIII] Central India

This region lies between the Ganges in the North and the river Godavari in the South and it is made up of Madhya Pradesh, parts of Orissa and Southern parts of Gujarat. The rainfall varies from 30" to 70". The area is rather hilly and depending on the quantity of rainfall, the vegetation zones have been divided into three types.

(a) Sal forests : These occupy the central parts of Madhya Pradesh and Orissa.

(b) Mixed deciduous forests : These occupy the central parts of Madhya Pradesh. The trees of *Tectona grandis (teak), Cassia fistula, Butea frondosa, Adina cordifolia, Acacia catecau, Odina woodier* etc. are grown.

(c) Thorn forests : These occupy the drier parts in the central region with comon plants such as *Acacia arabica, Zizyphus, Zylophus, Prosopis spicigera* etc.

[IX] Andamans

Andamans include the island groups of Andaman and the Nicobar islands. The coastal area is occupied by mangrove and beech forests and away from the coast and in hilly areas are the littoral evergreen forest of tall trees. There are some dry patches in the interior of the island. Most area of the island has been cleared in which paddy and sugarcane cultivation is done. The mangrove forests include species of *Rhizophora, Corallia brachiata, Areca triandra, Sonneralia caseolaris* etc. The common trees of littoral forests are *Morinda citrifolia, Manilkara littoralis, Pongamia pinnata, Cordia subcordata* etc. In the hilly areas, trees of species of *Terminalia, Dipterocarpus, Lagerstroemia* and *Calamus* (bamboo species) are found.

• SUMMARY

- Phytogeography is the study of origin, environmental relationships and distribution of plants both in time and space.
- The soils found in India are mainly alluvial, red, black, mountain, desert, laterite soil etc.
- The three seasons found in India are cold, hot and wet seasons.

- From the vegetation point of view, India can be divided into nine botanical regions, *e.g.*, Western Himalayas, Eastern Himalayas, Gangetic Plains, Malabar, The Deccan, Assam, West India Deserts, Central India and Andamans.

• Student Activity

1. What are fresh water communities?

2. How many types of soils are found in India? Name them.

3. How many seasons are found in India?

• TEST YOURSELF

Answer the following questions :

1. Mention the different kinds of plant communties found in India.
2. Describe the vegetation found in different regions of India.
3. Describe the climate of India and the major climatic zones of the country.
4. Give a brief account of the major botanical regions of India.
5. What is phytogeography? Mention the biomes.
6. What and where are the different soils found in India?
7. Write short notes on the following :
   (a) Western Himalayas (b) Eastern Himalayas (c) Gangetic Plains
   (d) West Indian deserts (e) Red soils (f) Black soils
   (g) Alluvial soils (h) Phytogeography (i) Indian climate.
8. The range from Kumaun to Kashmir is known as :
   (i) Eastern Himalayas (ii) Gangetic Plains (iii) Western Himalayas (iv) Assam
9. The zone where the annual rainfall is less than 50 cm is called :
   (i) Arid zone (ii) Desert soil (iii) Latosol (iv) Dry zone
10. The soil found in the west of Hyderabad is :
    (i) Red soil (ii) Desert soil (iii) Latosol (iv) Black soil
11. **Fill in the blanks :**
    (a) Alpine zone is found in ..... Himalayas.
    (b) Seaweeds are examples of ..... communities.
    (c) Soils formed due to siltation of rivers and sea are called ..... soils.
    (d) Heaviest rainfall is found in ..... region.

ANSWERS

8. (iii), **9.** (i), **10.** (iii), **11.** (a) Eastern (b) estuarine (c) alluvial (d) Assam.

APPENDICES

STRUCTURE

- Formation and Depletion of Ozone in the Stratosphere
- *Acid Rain*
- Greenhouse Effect
- Photochemical Smog

APPENDIX-1 FORMATION AND DEPLETION OF OZONE IN THE STRATOSPHERE

Ozone is an important chemical species present in the stratosphere. At a height of about 30 km, the concentration of ozone is about 10 ppm. The ozone layer present in the stratosphere acts as a protective shield for the life on earth. It strongly absorbs ultraviolet radiations from the sun in the region 220–330 nm and so protects the life on earth from severe radiation damage, such as DNA mutation and skin cancer. Therefore, only a small fraction of ultraviolet radiations reach the lower atmosphere and the earth's surface.

Ozone is formed in the stratosphere by the following photochemical reactions :

$$O_2 + h\nu \xrightarrow{242\ nm} O + O$$

$$O + O_2 + M \longrightarrow O_3 + M$$

where, M is a third body, *e.g.*, N_2.

The third body absorbs the excess energy produced by the above reaction, whereby the ozone molecule is stabilized. Thus, ozone is constantly formed in the stratosphere. However, it is also destroyed by chlorine, released due to volcanic activity and also by reaction with nitric oxide*, atomic oxygen and reactive hydroxyl radical. These substances are also present in the atmosphere, by the following reactions.

(a) $O_3 + NO \longrightarrow NO_2 + O_2$

(b) $O_3 + O \longrightarrow O_2 + O_2$

(c) $O_3 + HO^{\bullet} \longrightarrow O_2 + HOO^{\bullet}$

$HOO^{\bullet} + O \longrightarrow HO^{\bullet} + O_2$

Ozone, in the stratosphere, is also found to be destroyed by man-made chlorofluorocarbons (CFC), which are used as coolants in refrigerators, air-conditioners, propellants in aerosol sprays and in plastic foams, such as **thermocole** or **styrofoam.** The CFC molecules, escaping into the atmosphere, decompose to release chlorine in the ozone layer (by photodissociation) and each atom of chlorine, thus formed is capable of attacking several ozone molecules.

$$Cl + O_3 \longrightarrow ClO + O_2$$

The above reaction is followed by,

$$ClO + O \longrightarrow Cl + O_2$$

which regenerates chlorine atoms. So, a long chain process is involved, which conserves chlorine atoms. The environmental hazards of CFC's were recognised as early as 1970. In fact, temporary thinning in the stratospheric ozone layer, leading to the formation of **ozone hole** was actually detected over the Antarctica during September to November, 1985. Reported increase in cases of skin cancer in South Australia are also attributed to ultraviolet radiations reaching the earth temporarily, due to the depletion of ozone layer, over that part of the world.

* In atmosphere, nitric oxide (NO) comes from chemical and photochemical reactions in the atmosphere, supersonic jets, nuclear explosions etc. and chlorine (Cl_2) comes from CFC's and volcanoes; and HO comes from bio-mass burning and from natural water systems.

The detection of the **ozone hole** over Antarctica in 1985 attracted the attention of the whole scientific community in the world. The U.S.A. immediately banned the use of CFC's in spray cans. Further, in 1987, twenty four nations of the world signed the Montreal Protocol, which aims at 35 percent reduction in the global production of the CFC's by the year 1999. Efforts are still on to curb the use of CFC's. Simultaneously, efforts to produce chlorine-free substitutes have also started. In fact, synthesis of a product called HFC-134 has already been reported as an effective substitute for CFC.

[I] Effects of Ozone Layer Depletion

With the depletion of atmospheric ozone layer, the extent of ultraviolet radiation over the earth's atmosphere increases. Ultraviolet radiations are harmful to man's life. They cause skin cancer, swelling of skin, sun burns, burning sensation, skin ageing, leukemia, breast cancer, cataract of eyes, edema, haemorrhage, lungs injury, lung cancer, dizziness, visual impairment, premature ageing, DNA breakage, inhibition and alteration of DNA's replication and formation of DNA adduct and may even lead to death.

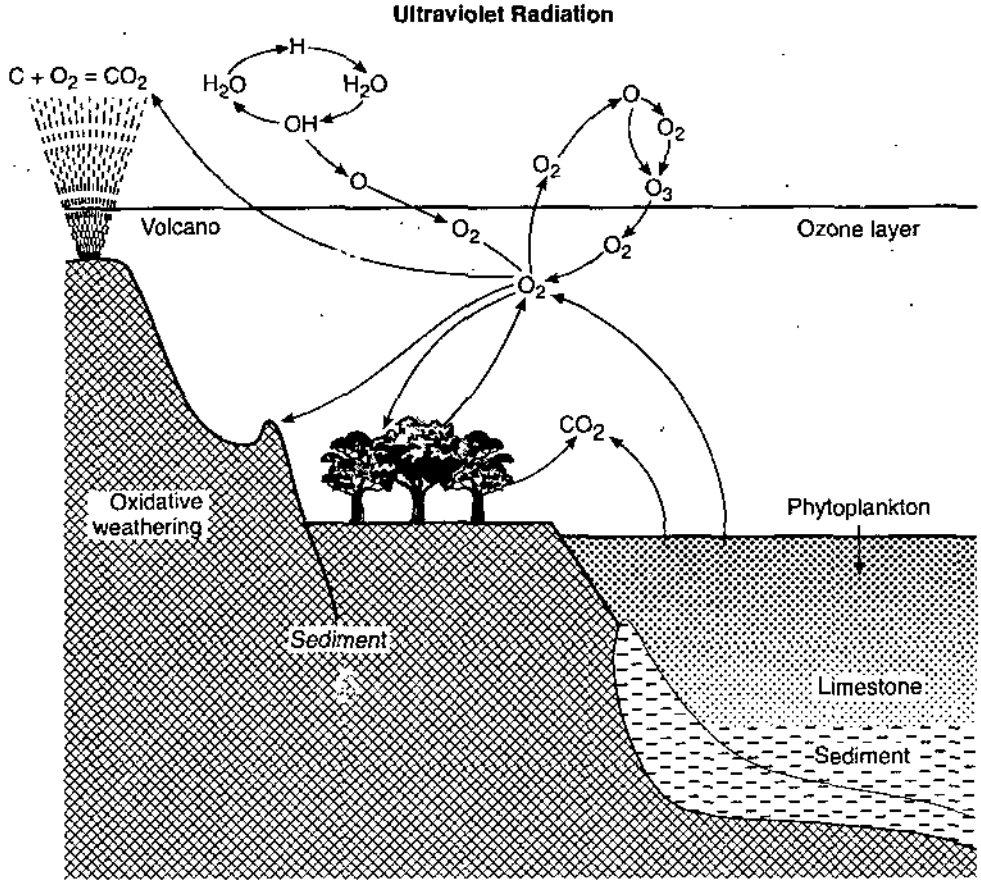


Fig. 1.

Effect of ozone on human beings.

Concentration (ppm)	0.2	0.3	0.8	1.0–3.0	9.0–10.0
Ill effects on health	No severe effect	Irritation of nose and throat	Lungs undergo genetic alteration within a week	Extreme fatigue after 2 hours	Chronic pulmonary edema

APPENDIX-2 ACID RAIN

The term **acid rain** was introduced by Robert Angus in 1872. It literally means presence of excessive acids in rain. Various industries and automobiles release acidic oxides like carbon dioxide, sulphur dioxide, nitrogen oxides etc. into the air. These oxides dissolve in moisture present in air and form corresponding acids which are present in clouds. As it rains, these acids slowly fall on earth as acid rain.

$$CO_2 + H_2O \longrightarrow \underset{\text{Carbonic acid}}{H_2CO_3}$$

$$SO_2 + H_2O \longrightarrow \underset{\text{Sulphurous acid}}{H_2SO_3}$$

$$2SO_2 + O_2 + 2H_2O \longrightarrow \underset{\text{Sulphuric acid}}{2H_2SO_4}$$

$$4NO_2 + 2H_2O + O_2 \longrightarrow \underset{\text{Nitric aicd}}{4HNO_3}$$

[I] Areas of Acid Rain

(1) In thickly populated cities the internal combustion engines of scooters, cars, trucks and buses emit CO, CO_2 and hydrocarbons.

(2) Large number of industries emit CO, CO_2, SO_2, SO_3, NO, NO_2 etc. in air. Out of these, acidic gases are absorbed by moisture in air to form acids.
So, more acid rains occur in thickly populated cities and industrial areas.

[II] Harmful Effects of Acid Rain

(1) Increased acidity of rain water causes damage to fresh water life like fishes etc. About 15,000 lakes in Sweden and 100 lakes in U.S.A. have become fishless.

(2) Many bacteria and blue green algae are killed due to acidification of water, thus disturbing the whole ecological balance.

(3) In the form of mist, it damages plant leaves.

(4) pH of rain water is lowered due to acid rain. It changes the rate of metabolism of animals.

(5) It accelerates the rate of corrosion of metals.

(6) Acid rain dissolves salts in soil like calcium carbonate and metals like aluminium which are passed on to ponds, lakes and rivers. It has toxic effect on aquatic life.

(7) Acid rain causes extensive damage to buildings and structural materials made of marble, limestone and slate etc. Attack of acid rain on marble is called **`stone leprosy'.**

(8) Corrosive damage is done to steel, zinc, oil-based paints and automobile coatings.

(9) *Possible effects on humans* : Lungs, skin, hair may be affected by acid rain. The heavy metals released by acid rain also may cause potential threat to human health. Acidification of drinking water reservoirs and concurrent increases in heavy metal concentrations may exceed public health limits and may cause injurious effects.

The extent of damage due to acid rain depends upon factors such as climate, topography, geology, biota and human acitivity. The phenomenon of acid rains is a highly interactive problem and remedial measures to control it are very expensive. The potential probability of acid rains is one of the major arguments aganst installation of coal-based thermal power stations. Keeping in view the potential ill effects of acid rains, it is highly desirable to control the pollutants (causing acid rains) at source, rather than treating the undesirable consequences of acid rains. The only practical approach to counter the problem of acid rains is to reduce SO_2 and NO_2 emissions.

APPENDIX-3 GREENHOUSE EFFECT

The term greenhouse was given by J. Fourier in 1827. The effect is also called **`global warming'.** Carbon dioxide present in the atmosphere traps infrared rays of sun and heat up the atmosphere. This is called **greenhouse effect.** Sun rays consist of UV rays, visible light and infrared radiations. Ozone layer absorbs UV rays and allows visible and infrared radiations to pass through it towards earth. Infrared rays are of short wavelengths, so, they can easily pass through the carbon dioxide layer in the atmosphere. These infrared rays heat up the atmosphere and objects on the earth. If carbon dioxide concentration is more, this gas forms a thick envelope around earth's surface and prevents heat from re-radiated out. So, the earth's surface is heated up more and the temperature rises.

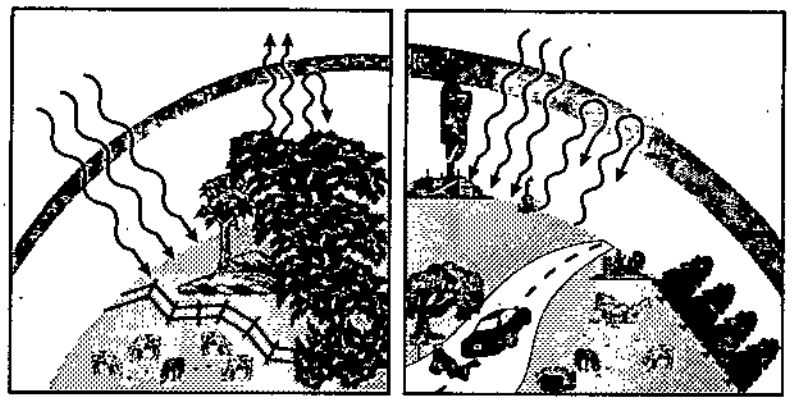


Fig. 2. The green house effect.

Thus, a greenhouse is a body which allows short wavelength incoming radiations but does not allow long wavelength radiations to escape.

[I] Greenhouse Gases

There are mainly four greenhouse gases, *viz.*, carbon dioxide, methane, nitrogen oxide and chlorofluoro carbons. The main source of carbon dioxide is combustion, fermentation and respiratory processes. Nitrogen oxide is formed as a result of deforestation, burning of biomass and nitrogeneous fertilizers. Methane is produced as a result of forest fires and decomposition processes.

In fact, the greenhouse gases are responsible for keeping our planet hot and thus we are able to sustain our lives on earth. If the greenhouse gases are very less or totally absent in the earth's atmosphere, then the average temperature on the earth would have been below 0°. However, if the concentration of greenhouse gases is greater, then they may trap too much of heat. This may threaten the very existence of life on the earth.

Oceans and biomass are the major sinks for the atmospheric carbon dioxide. Oceans convert carbon dioxide into soluble bicarbonates. The photosynthetic activity in the green plants increases with an increase in the level of carbon dioxide in the atmosphere. In the forests, lot of photosynthetic activity occurs. They also act as large reservoirs of fixed but readily oxidisable carbon in the form of wood, vegetation and humus. So, forests maintain a balance in the atmospheric carbon dioxide level. Therefore, deforestation definitely upsets this balance, whereby the atmospheric carbon dioxide level increases. According to an estimate, the atmospheric carbon dioxide content has increased by 25 percent during the last two centuries. This is mainly attributed to the industrial revolution over these two centuries.

The earth's natural atmospheric cleanser—rain—may wash excess greenhouse gases out of the atmosphere. But until rates of greenhouse gases slow their rapid increases or actually begin to decrease, the planet will get warmer.

[II] Consequences of Greenhouse Effect

(1) It heats up earth surface and evaporates the surface water.

(2) Ice of polar region and glacials may melt, increasing the sea level and flooding of low level areas of the world.

(3) Increase in global temperature affects food production.

(4) At higher altitudes, carbon dioxide undergoes photochemical reaction to form carbon monoxide which has a toxic effect.

APPENDIX-4 PHOTOCHEMICAL SMOG

Smog is a term chosen by the Glasgow public health official Des Voeux at the beginning of the twentieth century to describe the smoky fogs that characterised coal burning cities of the time. The word *smog* is formed by adding the words *smoke* and *fog* together and has persisted as a description of this type of urban atmosphere. It has more and more been used to describe ***photochemical smog***, the haze that became a characteristic of the Los Angeles Basin from the 1940s. So, we can infer that **smog *is a mixture of smoke (from coal combustion) and fog in suspended droplet form.*** There are *two* types of smog :

(a) ***London smog*** is a mixture of coal smoke and fog. The fog part is mainly a mixture of sulphur dioxide and sulphur trioxide and humidity. It is generally bad in the early morning hours and becomes worse after sunrise, due to sunlight induced oxidation of sulphur dioxide to sulphur trioxide, followed by reaction with humidity. *This yields sulphuric acid aerosol. Such a smog causes* **bronchial irritation** and also **acid rain.** Smog also causes **poor atmospheric visibility.**

(b) ***Los Angeles smog (photochemical smog)*** is not related to smoke or fog. It is worst in the sunshine with peaks in the afternoon. The oxides of nitrogen (NO and NO_2) alongwith carbon dioxide, water vapours, carbon monoxide and unburnt hydrocarbon particles (emitted from automobile exhausts) and also sulphur dioxide cause Los Angeles smog.

It is initiated by the photochemical dissociation of nitrogen dioxide and the resulting secondary reactions involving unsaturated hydrocarbons, other organic compounds and free radicals, leading to the formation of organic peroxides and ozone. The most important reaction is the dissociation of nitrogen dioxide in ultraviolet light from sunlight.

$$N_2(g) + O_2(g) \xrightarrow[\text{or furnaces}]{\text{in I.C. engines}} \underset{\text{Nitric oxide}}{2NO(g)}$$

or

$$2NO(g) + O_2(g) \longrightarrow \underset{\text{Nitrogen dioxide}}{2NO_2(g)}$$

$$NO_2 \xrightarrow{\text{UV light}} NO(g) + [O]$$

$$O_2(g) + [O] \longrightarrow O_3(g)$$

Hydrocarbons + O_3, O_2, O, NO_2, NO → Peroxides, peroxyacetyl nitrate (PAN), formaldehyde, ozone, aldehyde, acrolein, etc. (*Oxidized hydrocarbons*). These oxidized hydrocarbons and ozone in the presence of humidity cause photochemical smog, which dissipates at night. The oxidation of sulphur dioxide can also occur by interaction with the free radical $HO^{\bullet}$ present in **photochemical smog.**

$$SO_2 + HO^{\bullet} \longrightarrow HOSO_2^{\bullet}$$

$$HOSO_2^{\bullet} + O_2 \longrightarrow HOSO_2 \cdot O_2^{\bullet}$$

$$HOSO_2 \cdot O_2^{\bullet} + NO \longrightarrow \underset{\text{(Sulphate)}}{HOSO_2O^{\bullet}} + NO_2$$

Photochemical smog is sometimes called ***summer smog***, because unlike the classical London type smog, it is more typical in summer at many localities, often because it requires long hours of sunshine to build up. When photochemical smog was first observed in Los Angeles, people believed them to be much the same as the smogs of London and Pittsburgh. A photochemical smog :

(i) causes irritation to eyes and lungs,

(ii) causes several damages to plants,

(iii) causes irritation to nose, throat, and

(iv) causes increased changes of asthamatic attack and mortality.

[I] Measures to Reduce Smog

We can protect overselves from smog by decreasing the nitrogen oxides and hydrocarbon levels of the air by providing catalytic converters in modern automobiles. These reduce the quantity of hydrocarbons as well as unwanted products, *e.g.*, nitrogen dioxide going out of the exhaust pipes of automobiles. It may be pointed here that these catalysts get quickly *poisoned* by lead compounds (like TEL), therefore, such automobiles require unleaded petrol.

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