4
Chapter

Biodiversity and its Conservation

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4.1 DEFINITION OF BIODIVERSITY

Biological diversity or biodiversity refers to the variety of life forms: the different plants, animals and microorganisms, the genes they contain, and the ecosystems they form. This living wealth is the product of hundreds of millions of years of evolutionary history. The process of evolution means that the pool of living diversity is dynamic: it increases when new genetic variation is produced, a new species is created or a novel ecosystem formed; it decreases when the genetic variation within a species decreases, a species becomes extinct or an ecosystem complex is lost. The concept emphasises the interrelated nature of the living world and its processes.

In the convention of Biological diversity (1992), biodiversity has been defined as *the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part.* Thus, biodiversity can be defined as 'the totality of genes, species and ecosystems of a region'. Biological diversity is usually considered at three different levels: genetic diversity, species diversity and ecosystem diversity.

4.2 LEVELS OF BIODIVERSITY

Biodiversity is usually explored at three levels—genetic diversity, species diversity and ecosystem diversity. These three levels work together to create the complexity of life on earth.

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4.2.1 Genetic Diversity

Genetic diversity refers to the variety of genetic information contained in all of the individual plants, animals and microorganisms. Genetic diversity is the variety of genes within a species. Genetic diversity occurs within and between populations of species as well as between species. Each species is made up of individuals that have their own particular genetic composition. This means a species may have different populations, each having different genetic compositions. To conserve genetic diversity, different populations of a species must be conserved.

Genes are the basic units of all life on earth. They are responsible for both the similarities and the differences between organisms. When the genes within the same species show different versions due to new combinations, it is called genetic variability or genetic diversity.

Genetic diversity refers to the variation of genes within species. This covers genetic variation between distinct populations of the same species, such as the four varieties of white-cheeked rosella, *Platycercus eximius*. It also covers genetic variation within a population, which tends to be relatively high in widespread eucalypts such as *Eucalyptus cloeziana, E. delegatensis,* and *E. saligna*. Genetic diversity can be measured using a variety of DNA-based and other techniques.

4.2.2 Species Diversity

Species diversity is the variety of species within a habitat or a region. Some habitats, such as rainforests and coral reefs, have many species. Others, such as salt flats or a polluted stream, have fewer. This is the variability found within the population of a species or between different species of a community. It represents broadly the species richness and their abundance in a community.

Species diversity refers to the variety of species. Aspects of species diversity can be measured in a number of ways. Most of these ways can be classified into three groups of measurement: species richness, species abundance and taxonomic or phylogenetic diversity.

Measures of species richness count the number of species in a defined area. Measures of species abundance sample the relative numbers among species. A typical sample may contain several very common species, a few less common species and numerous rare species. Measures of species diversity that simplify information on species richness and relative abundance into a single index are in extensive use. Another approach is to measure taxonomic or phylogenetic diversity, which considers the genetic relationships between different groups of species. These measures are based on analysis which results in a hierarchical classification usually represented by a 'tree' that depicts the branching pattern which is thought to best represent the phylogenetic evolution of the taxa concerned.

Different measures of taxonomic diversity emphasise various taxic characteristics and relationships. The species level is generally regarded to be the most appropriate to consider the diversity between organisms.

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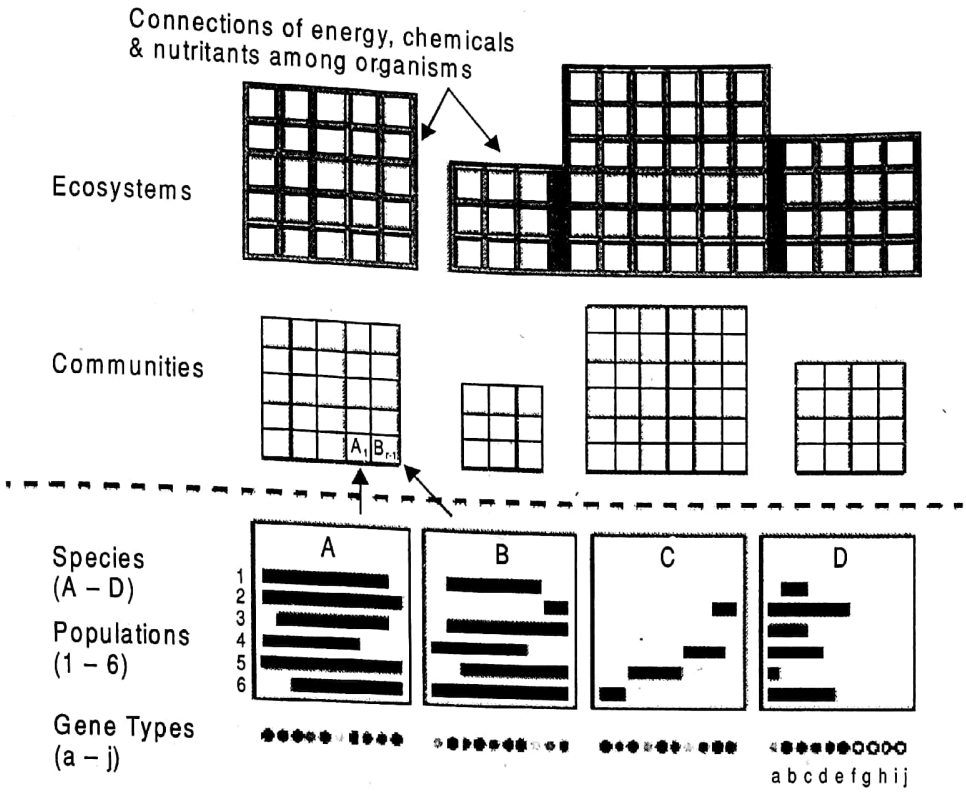

Fig. 4.1 Levels of Biodiversity

4.2.3 Ecosystem Diversity

Ecosystem diversity encompasses the broad differences between ecosystem types, and the diversity of habitats and ecological processes occurring within each ecosystem type. Generally, these systems use a combination of a habitat type definition with a climatic descriptor; for example, tropical moist forest, or temperate grassland. Some systems also incorporate global biogeography to account for differences in biota between regions of the world which may have very similar climate and physical characteristics.

An ecosystem is a community of organisms and their physical environment interacting together. An ecosystem may be as large as the Great Barrier Reef or as small as the back of a spider crab's shell, which provides a home for plants and other animals, such as sponges, algae and worms. This is the diversity of ecological complexity showing variations in ecological niches, tropic structure, food-webs, nutrient cycle etc. The ecosystems also show variations with respect to physical parameters like moisture, temperature, altitude, precipitation etc. We may consider diversity in forest ecosystem which is suppose to have mainly dominance of trees. (see figure 4.2)

4.3 BIO-GEOGRAPHICAL CLASSIFICATION OF INDIA

India, being a vast country, shows a great diversity in climate, topography and geology and hence the country is very rich in terms of biological diversity. India is the seventh largest country in the world and Asia's second largest nation with an area of 3,287,263 sq km encompassing a varied landscape rich in natural resources. India is shielded by the world's highest mountains, the Himalayas, in

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the north. The southern part of India takes the shape of a peninsula and divides the Indian Ocean into the Bay of Bengal to the southeast and the Arabian Sea to the southwest. The southern tip of Kanniyakumari is washed by the Indian Ocean. The Andaman and Nicobar Islands in the Bay of Bengal and the Lakshadweep group of islands in the Arabian sea are also a part of India.

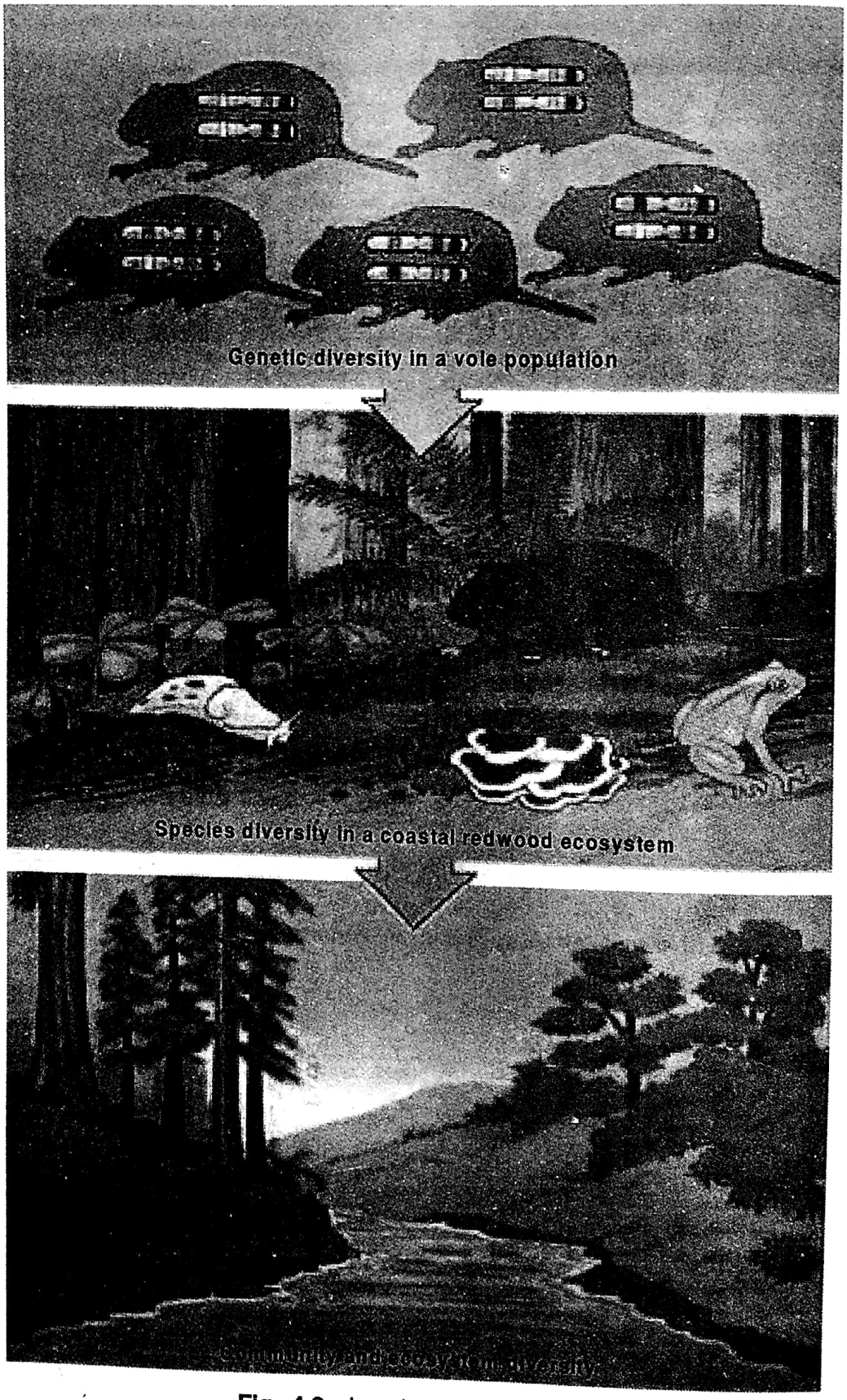

Fig. 4.2 Levels of biodiversity

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India has a great diversity of natural ecosystems from the cold and high Himalayan ranges to the sea coasts, from the wet northeastern green forests to the dry northwestern arid deserts, different types of forests, wetlands, islands and the oceans. The climate of India is determined by the southwest monsoon between June and October, the northeast monsoon between October and November and dry winds from the north between December and February. From March to May the climate is dry and hot. **The country has 10 different biogeographic zones and 26 biotic provinces.** *A biographic zone is a large distinctive unit of similar ecology, biome representation, community and species,* e.g. Trans Himalaya, The Deccan Peninsula etc. *A biotic province is secondary unit with a biogeographic zone, giving weight to particular community separated by dispersal barrier or gradual change in environmental factors.*

Table 4.1

Zone Name	*Existing Protected Areas*			*Biotic Provinces*
	% of India	*Number of National Parks and Wildlife Sanctuaries*	*% of Zone*	
Trans-Himalaya	5.62	7	9.20	Ladakh mountains, Tibetan plateau
Himalaya	6.41	67	9.92	Northwest, West Central and East Himalayas
Desert	6.56	6	7.45	Thar, Kutch
Semi-arid	16.60	91	2.80	Punjab plains, Gujarat Rajputana
Western Ghats	4.03	56	10.12	Malabar plains, Western Ghats
Deccan Peninsula	41.99	137	3.71	Central highlands, Chhotta Nagpur, Eastern highlands, Central Plateau, Deccan South
Gangetic Plain	10.79	36	2.16	Upper and Lower Gangetic plains
Coasts	2.52	26	6.79	West and East coast, Lakshadweep
North-East	5.21	37	2.54	Brahmaputra valley, Northeast hills
Islands	0.25	103	18.54	Andaman and Nicobar

Source: Wildlife Protected Area Network in India: A Review, Wildlife Institute of India, 2000.

1. The Trans-Himalayan Region

This area is very cold and arid (4,500-6,000 m above mean sea level). The only vegetation is a sparse alpine steppe. Extensive areas consist of bare rock and glaciers.

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The faunal groups best represented here are wild sheep and goats (chief ancestral stock), ibex, snow leopard, marbled cat, marmots and black-necked crane.

2. The Himalayan Region

The fantastic altitude gradient results in the tremendous biodiversity of the Himalayan region. Flora and fauna vary according to both altitude and climatic conditions: tropical rainforests in the Eastern Himalayas and dense subtropical and alpine forests in the Central and Western Himalayas. The lower levels of the mountain range support many types of orchids. On the eastern slopes, rhododendrons grow to tree height.

Animals of Himalayas show several behavioural and physiological adaptations. Sambar and muntjac are found in the subtropical foothills; serow, goral and the Himalayan thar are found in the temperate and subalpine regions; snow leopard and brown bear inhabit the alpine region. Carnivores are the most elusive of all mammals in the Himalayas. There are a variety of carnivores in the higher mountains, some of which are rare and threatened with extinction.

3. The Indian Desert

The natural vegetation consists of tropical thorn forests and tropical dry deciduous forests, sandy deserts with seasonal salt marshes and mangroves are found in the main estuaries. Typical shrubs are growing on sand dunes. Sewan grass covers extensive areas called *pali*.

Thar desert possesses most of the major insect species. 43 reptile species and moderate bird endemism are found here. No niche of the Thar is devoid of birds. The black buck was once the dominant mammal of the desert region now confined only to certain pockets. The gazelle is the only species of the Indian antelope of which the females have horns. Nilgai the largest antelope of India and the wild ass, a distinct subspecies, is now confined to the Rann of Kutch which is also the only breeding site in the Indian subcontinent for the flamingoes. Other species like desert fox, great Indian bustard, chinkara and desert cat are also found.

4. The Semi-Arid Region

The semi-arid region in the west of India includes the arid desert areas of Thar and Rajasthan extending to the Gulf of Kutch and Cambay and the whole Kathiawar peninsula.

The natural vegetation consists of tropical thorn forests and tropical dry deciduous forests, moisture forests (extreme north) and mangroves. The sandy plains have a few scattered trees of Acacia and Prosopis. The gravelly plains have Calotropis, Gymnosporia, etc. The rocky habitats are covered by bushes of Euphorbia while species of Salvadora and Tamarix occur mainly near saline depressions. The lion of Gir is the endemic species in this zone.

5. The Western Ghats

They cover only 5% of India's land surface but are home to more than about 4,000 of the country's plant species of which 1800 are endemic. The monsoon forests

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occur both on the western margins of the ghats and on the eastern side where there is less rainfall. This zone displays diversity of forests from evergreen to dry deciduous.

The Nilgiri langur, lion tailed macaque, Nilgiri tahr, Malabar grey hornbill and most amphibian species are endemic to the Western Ghats.

6. The Deccan Peninsula

The Deccan Peninsula is a large area of raised land covering about 43% of India's total land surface. It is bound by the Sathpura range on the north, Western Ghats on the west and Eastern Ghats on the east. The elevation of the plateau varies from 900 m in the west to 300 m in the east. There are four major rivers that support the wetlands of this region which have fertile black and red soil. Large parts are covered by tropical forests. Tropical dry deciduous forests occur in the northern, central and southern part of the plateau. The eastern part of the plateau in Andhra Pradesh, Madhya Pradesh and Orissa has moist deciduous forests.

Fauna like tiger, sloth bear, wild boar, gaur, sambar and chital are found throughout the zone along with small relict populations of wild buffaloes, elephants and barasingha.

7. The Gangetic Plain

The Gangetic plain is one of India's most fertile regions. The soil of this region is formed by the alluvial deposits of the Ganges and its tributaries. The four important surface differences recognised in the geomorphology of the plains are

- **Bhabar:** Pebble studded zone with porous beds.
- **Terai:** Marshy tract.
- **Bhangar:** Older alluvium of the flood plain.
- **Khadar:** Newer alluvium.

The Gangetic plains stretching from eastern Rajasthan through Uttar Pradesh to Bihar and West Bengal are mostly under agriculture. The large forest area is under tropical dry deciduous forest and the southeastern end of the Gangetic plain merges with the littoral and mangroves regions of the Sunderbans.

The fauna includes elephants, black buck, gazelle, rhinoceros, Bengal florican, crocodile, freshwater turtle and a dense waterfowl community.

8. The Coastal Region

The natural vegetation consists of mangroves. Animal species include dugong, dolphins, crocodiles and avifauna. There are 26 species of fresh water turtles and tortoises in India and 5 species of marine turtles, which inhabit and feed in coastal waters and lay their eggs on suitable beaches. Tortoise lives and breed mainly on the land.

Over 200,000 Olive Ridley turtles come to Orissa to nest in the space of three or four nights. The highest tiger population is found in the Sunderbans along the east coast adjoining the Bay of Bengal.

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Lakshadweep consists of 36 major islands—12 atolls, 3 reefs and 5 submerged coral banks—make up this group of islands more than three hundred kilometres to the west of the Kerala coast. The geographical area is 32 sq km and the usable land area is 26.32 sq km. The fauna consists mainly of four species of turtles, 36 species of crabs, 12 bivalves, 41 species of sponges including typical coral, ornamental fishes and dugongs. A total of 104 scleractinian corals belonging to 37 genera are reported.

9. The North-East

Biological resources are rich in this zone. The tropical vegetation of northeast India is rich in evergreen and semi-evergreen rain forests, moist deciduous monsoon forests, swamps and grasslands.

Mammalian fauna includes 390 species of which 63% are found in Assam. The area is rich in smaller carnivores. The country's highest population of elephants is found here.

10. The Indian Islands

It is a group of 325 islands: Andaman is the north and Nicobar in the south. The two are separated by about 160 km of the Ten Degree Channel of the sea. The rainfall is heavy, with both Northeast and Southwest monsoons. At present, 21

Fig. 4.3 Biogeographical regions of India with their prominent species

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of the 325 islands in the Andaman and Nicobar Islands are inhabited. Many unique plants and animals are found here. About 2,200 species of higher plants are found here of which 200 are endemic. The Andaman and Nicobar Islands have tropical evergreen forests and tropical semi-evergreen forests as well as moist deciduous forests, littoral and mangrove forests.

112 endemic species of avifauna, the Andaman water monitor, giant robber crab, 4 species of turtles, wild boar, Andaman day gecko and the harmless Andaman water snake are found only in these islands. The Narcondam hornbill, found only in Narcondam, is a large forest bird with a big beak. Coral reefs are stretched over an area of 11,000 sq km in the Andamans and 2,700 sq km in Nicobar.

4.4 VALUE OF BIODIVERSITY

The values of biodiversity in terms of its commercial utility, ecological services, social and aesthetic value is enormous. The multiple uses of biodiversity or biodiversity value have been classified by McNeely *et al* in 1990 as follows:

4.4.1 Consumptive Use Value

Goods that are consumed locally; do not appear in Gross Domestic Product (GDP) because they are neither bought nor sold. Consumptive use value can be estimated for products by determining how much people would have to pay to buy equivalent products if local sources were not available.

Consumptive use values relate to the value of goods produced by the ecosystem that can be consumed and used by people. Consumptive and productive use values are closely related to biodiversity because without biodiversity the productivity of the ecosystem responsible for the production of these goods would be significantly impaired. These are direct use values where the biodiversity product can be harvested and consumed directly e.g. fuel, food, drugs, fiber etc.

- 50% of rainforest tree species are used by indigenous people for non-fuel products.
- 80% of the world's population relies on traditional medicines from plants and animals.
- Protein from wild game, fish and insects is vital to people in many countries, including the US.
- Fuel wood and animal dung provides energy for people in many countries.

4.4.2 Productive Use Value

Products that are **harvested and sold in markets**; these are the commercially usable values where the product is marked and sold. Standard economic methods value these products as the **price paid at the first point of sale minus the costs incurred up to that point** (rather than the final retail price). Approximately **4.5% ($87 billion) of the US GDP depends on wild species**; likely to be **higher in**

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developing nations. These may include the animal products like tusk of elephant, musk from musk deer, silk from silk worm, wool from sheep, fur from many animals, lac from lac insects etc., all of which are traded in the market.

Forests: Wood products, game, fruits, gum, resins, medicinal plants.

New medicines: AIDS drugs, cancer drugs.

4.4.3 Social Value

These are the values associated with the social life, customs, religion and psycho-spiritual aspects of the people. The cultural value of biological diversity conservation for present and future generations is an important reason for conserving it today. Human cultures coevolve with their environment, and the conservation of biological diversity can be important for cultural identity. Many of the plants and animals are considered holy and sacred in our country like tulsi, peepal, mango, lotus, bael, cow, snake, bull, peacock, owl etc.

4.4.4 Ethical Value

It is also sometimes known as existence value. People love live, a phenomenon called "biophilia" by E.O. Wilson (1984). Sometimes, our feeling for biodiversity is revealed in the way we spend our money; sometimes they are not. Economists are trying to devise methods for estimating the monetary value of the blue whales and harp seals for people whose only relationship with them is that they know that they exist.

4.4.5 Aesthetic Value

The aesthetic values of our natural ecosystems and landscapes contribute to the emotional and spiritual well-being of a highly urbanised population. Natural and wild landscapes are aesthetically pleasing and provide opportunities to get away from human-dominated landscapes. They also provide opportunities for recreational activities such as hiking, canoeing, bird watching and nature photography. In North America, protected wild areas where indigenous organisms live undisturbed give people a sense of satisfaction in knowing that there are bears and wolves and rare plants and insects that still exist on their continent. Ecotourism (enjoyment of aesthetical value) is estimated to generate about 12 billion dollars of revenue annually that roughly gives the aesthetic value of biodiversity.

4.4.6 Option Values

A species' **potential to produce economic benefits to society in the future**; our need for species, we once ignored is often important and unpredictable. Time after time, we have rushed back to nature's cupboard for cures to illnesses or for infusions of tough genes from wild plants to save our crops from pest outbreaks.

When we assess the instrumental value of species, we generally focus on their usefulness hear and now, but this is a shortsighted viewpoint as revealed in our

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discussion of medicinal research and biodiversity. Our rudimentary understanding of biology and ecology has leaved an enormous gap between the currently realised values of a species and its potential future value. This gap is particularly wide because we have vague idea of what our future lives will be like—technologically, culturally and ecologically. It may be difficult to guess at the potential ecological role that a species might assume in the future. It would certainly have taken a very prescient biologists to guess that the shrewlike mammals that shared the earth with dinosaurs would lead to the earth-dominating *Homo sapiens*. The evolution of our scientific knowledge has already taught us that: keep options alive. We must take this approach because we know so little. We can never say of species, a part of biodiversity that lacks of values. The problem is **we don't know which species have the benefits**; so, it is **important to preserve them all**.

4.4.7 Ecosystem Service Value

A non-consumptive use value related to self-maintenance of the ecosystem and various important ecosystem services has been recognised. "*Goods and Services" provided by ecosystems include:*

- *Provision of food, fuel and fiber*;
- *Provision of shelter and building materials*;
- *Purification of air and water*;
- *Detoxification and decomposition of wastes*;
- *Stabilization and moderation of the Earth's climate*;
- *Moderation of floods, droughts, temperature extremes and the forces of wind;*
- *Generation and renewal of soil fertility, including nutrient cycling*;
- *Pollination of plants, including many crops*;
- *Control of pests and diseases*;
- *Maintenance of genetic resources as key inputs to crop varieties*;
- *Livestock breeds, medicines, and other products*; and
- *Ability to adapt to change.*

4.5 BIODIVERSITY AT GLOBAL, NATIONAL AND LOCAL LEVEL

4.5.1 Global Biodiversity

Conservative estimates of the existing biodiversity is ten million species but if estimates for insects are correct then it could be around 30 million species, we have till now estimated about 1.4 million species.

Globally, we have roughly 1,70,000 flowering plants, 30,000 vertebrates and about 2,50,000 other groups of species that have been described.

Terrestrial biodiversity of the earth is best describes as biomes, which are the largest ecological units present in different geographic areas and are named after the dominant vegetation, e.g. the tropical rainforest, tall grass prairies etc. There is

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an estimated 1,25,000 flowering plant species in tropical forests. Temperate forests have much less biodiversity, but there is much better documentation of the species.

It is interesting to know that marine diversity is even much higher than terrestrial biodiversity and ironically, they are still less known and described.

4.5.2 National Biodiversity

Every country is characterised by its own biodiversity depending mainly on its climate. India has a rich biodiversity depending mainly on its climate. India has a rich biological diversity of flora and fauna. Overall 6% of global species are found in India. It is estimated that India ranks 10th among the plant rich countries of the world, 11th in terms of the number of endemic species of higher vertebrates and 6th among the centre of diversity and origin of agricultural crop.

India has a rich and varied heritage of biodiversity, encompassing a wide spectrum of habitats from tropical rainforests to alpine vegetation and from temperate forests to coastal wetlands. India figured with two hotspots—the Western Ghats and the Eastern Himalayas—in an identification of 18 biodiversity hotspots carried out in the eighties (Myers, 1988). Recently, Norman Myers and a team of scientists have brought out an updated list of 25 hotspots (Myers et al. 2000). In the revised classification, the 2 hotspots that extend into India are The Western Ghats/Sri Lanka and the Indo-Burma region (covering the Eastern Himalayas); and they are included amongst the top eight most important hotspots. In addition, India has 26 recognised endemic centres that are home to nearly a third of all the flowering plants identified and described to date.

Of the estimated 5–50 million species of the world's biota, only 1.7 million have been described to date (Groombridge, and Jenkins, 2000), and the distribution is highly uneven. About seven per cent of the world's total land area is home to half of the world's species, with the tropics alone accounting for 5 million. India contributes significantly to this latitudinal biodiversity trend. With a mere 2.4% of the world's area, India accounts for 7.31% of the global faunal total with a faunal species count of 89,451 species (MoEF, 1999).

India has two major realms called the Palaearctic and the Indo-Malayan, and three biomass, namely the tropical humid forests, the tropical dry/deciduous forests, and the warm desert/semi-deserts.

Some salient features of India's biodiversity have been mentioned below.

- India is one of the 12 centres of origin of cultivated plants.
- India has 5 world heritage sites, 12 biosphere reserves, and 6 Ramsar wetlands.
- Amongst the protected areas, India has 88 national parks and 490 sanctuaries covering an area of 1.53 lakh sq. km.

4.5.3 Regional or Local Biodiversity

R.H. Whittaker, (1972) described three terms for measuring biodiversity over geographic scales:

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Alpha (α-) diversity refers to diversity within a particular area, community or ecosystem, and is measured by counting the number of taxa within the ecosystem (usually species). It refers to the diversity of organism sharing the same community or habitat.

Beta (β-) diversity is species diversity between community or ecosystems; this involves comparing the number of taxa that are unique to each of the ecosystems. There are differences in species composition of communities along environmental gradients, e.g., altitude, moisture etc.

Gamma (γ-) diversity is a measure of the overall diversity for different ecosystems within a region. It refers to the diversity of the habitats over the total land scape or geographical area.

4.6 INDIA AS A MEGA-DIVERSE NATION

India, being a vast country, shows a great diversity in climate, topography and geology and hence the country is very rich in terms of biological diversity. India's biological diversity is one of the most significant in the world, since India has only 2% of the total landmass of the world containing about 6% of the world's known wildlife.

India is one of the 12 mega-diverse countries in the world. The MOEF, GOI (2000) records 47,000 species of plants and 81,000 species of animals which are about 7% and 6.5% respectively of global flora and fauna.

4.6.1 Endemism

Species which are restricted only to a particular area are known as endemic. The endemism of Indian biodiversity is high. About 33% of the country's recorded flora are endemic to the country and are concentrated mainly in the North-East, Western Ghats, North-West Himalaya and the Andaman and Nicobar islands.

Of the 49,219 plant species, 5150 are endemic and distributed into 141 genera under 47 families corresponding to about 30% of the world's recorded flora, which means 30% of the world's recorded flora is endemic to India. Of these endemic species, 3,500 are found in the Himalayas and adjoining regions and 1600 in the Western Ghats alone. About 62% of the known amphibian species are endemic with the majority occurring in the Western Ghats.

Nearly 50% of the lizards of India are endemic with a high degree of endemicity in the Western Ghats. India's record in agro-biodiversity is equally impressive. There are 167 crop species and wild relatives. India is considered to be the centre of origin of 30,000-50,000 varieties of rice, pigeon-pea, mango, turmeric, ginger, sugarcane, gooseberries etc. and ranks seventh in terms of contribution to world agriculture.

4.6.2 Centre of Origin

A large number of species are known to have originated in India. Nearly 5000 species of flowering plants had their origin in India. India is a centre of crop

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diversity—the homeland of 167 cultivated species and 320 wild relatives of crop plants.

4.6.3 Marine diversity

Along 7500 km long coastline of our country in the mangroves, estuaries, coral reefs, back water etc. there exists a rich biodiversity. More than 340 species of corals of the world are found here.

A large proportion of the Indian biodiversity is still unexplored. There are about 93 major wetlands, coral reefs and mangroves which need to be studied in detail.

Coral reefs are undersea living communities with self-contained steady-state ecosystems and well-defined tropic levels of producers and consumers. Reefs are home to thousands of marine creatures and make available all basic necessities like food, shelter and breeding areas to their refugee floras and faunas. Human expansion and development is one the prime threats to coral reefs; various anthropogenic activities raise pollutants and cause eutrophication in water that boosts the growth of such organisms like sponges, which out-compete the corals for space on crowded reefs.

Runoff, industrial outflows and huge sewage disposals are ruthlessly degrading the delicate and frail coral reef frameworks. Excess fishing has considerably reduced the population of reef fishes in many parts of the world leading to imbalances in coral reef ecology and allowing more competitive organisms to prevail over the reefs. Usage of explosives or poisons by fishermen, to get more yields from sea in some regions, is severely damaging the corals. Natural disturbances like hurricanes, typhoons, powerful stroms, etc. also cause irreparable damage to coral reefs. Ever minor changes in the susceptible reef environment can bring detrimental impact on the health of entire coral colonies.

4.7 HOT SPOTS OF BIODIVERSITY

Hot spots are areas that are extremely rich in species, have high endemism, and are under constant threat. The term was introduced by Mayer's (1988). The hot spots covering less than 2% of the world's land area are found to have 50% of terrestrial biodiversity. According to Mayer's *et al.* (2000), an area is designated as a hot spot when it contains at least 0.5% of the plant species as endemic.

About 40% of terrestrial plants and 25% of vertebrates' species are endemic and found in these hot spots. After the tropical rain forest, the second highest numbers of endemic plant species are found in the Mediterranean (Mittermeier). Broadly, these hot spots are:

1. Tropical Andes
2. Meso America
3. Caribbean
4. Brazil's Atlantic Forest
5. Choc. Darien/Waetern Ecuador
6. Brazil's Cerrado
7. Central Chile
8. California Floristic Province
9. Madagascar
10. Western African Forest

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11. Cape Floristic Province
12. Succulent Karoo
13. Mediterranean Basin
14. Caucasus
15. Sundaland
16. Wallacea
17. Philippines
18. Indo-Burma
19. South Central China
20. Western Ghats/Sri Lanka
21. South West Australia
22. New Caledonia
23. New Zealand
24. Polynesia/Micronesia
25. Eastern Arc and Coastal Forest of Kenya and Tanzania

These are the areas of high diversity, endemism and are also threatened by human activities. More than 1/6th of world's population, most of whom are desperately poor people, live in these areas. Among the 25 hot spots of the world, two are found in India extending into neighbouring countries—the Western Ghats/ Sri Lanka and the Indo-Burma region (covering the Eastern Himalayas). These areas are particularly rich in floral wealth and endemism, not only in flowering plants but also in reptiles, amphibians, swallow-tailed butterflies, and some mammals. The silent features of Indian Hotspots are as follows :

4.7.1 Eastern Himalayas

Phytogeographically, the Eastern Himalayas form a distinct floral region. The area comprises Nepal, Bhutan, and neighbouring states of northern India, along with a continuous sector of the Yunnan province in southwest China. Although all Himalayan forests lie well north of the Tropic of Cancer, and some of them are at altitudes of 1780 to 3500 metres (rather akin to temperate forests in physiognomy and structure), they can be considered tropical forests since they occur largely within the climatic tropics.

It is believed that forest cover in the Eastern Himalayas has dwindled from 340,000 km^2 to 110,000 km^2 with a mere 53,000 km^2 of primary forests. Despite this loss, the north-eastern region is home to some botanical rarities. One of these is the *Sapria* Himalayana, a parasitic angiosperm that has been sighted only twice since 1836.

This region is the meeting ground of the Indo-Malayan and Indo-Chinese biogeographical realms as well as the Himalayan and Peninsular Indian elements, formed when the peninsular plate struck against the Asian landmass, after it broke off from Gondwana land.

- The Eastern Himalayas display an ultra-varied topography, a factor that fosters species diversity and endemism.
- Many deep and semi-isolated valleys are exceptionally rich in endemic plant species. In Sikkim, in an area of 7298 km^2, of the 4250 plant species, 2550 (60%) are endemic (Myers, 1988). In India's sector of the area, there are about 5800 plant species, of which roughly 2000 (36%) are endemic.
- In Nepal, there are around 7000 plant species, many of which overlap with those of India, Bhutan, and even Yunnan. Of these species, at least 500 (almost 8%) are believed to be endemic to Nepal.

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- Bhutan possesses an estimated 5000 species, of which as many as 750 (15%) are considered to be endemic to the Eastern Himalayas.
- The numerous primitive angiosperm families found in this region include Magnoliaceae, Degeneriaceae, Himantandraceae, Eupomatiaceae, Winteraceae, Trochodendraceae, Tetracentraceae, and Lardizalbaleaceae. The primitive genera are *Alnus, Aspidocarya Betula, Decaisnea, Euptelea, Exbucklandia, Haematocarpus, Holboellia, Houttuynia, Magnolia, Mangelietia, Pycnarrhena,* and *Tetracentrol* (Malhotra and Hajra, 1977).
- Studies have shown that north-east India along with the contiguous region of the Chinese provinces of Yunnan and Schezwan is an active centre of organic evolution and is the cradle of flowering plants.
- This has now been confirmed by studies in south-east China where an altogether new large mammal (*Muntiacus gongshanensis*) and four new genera of flowering plants (*Xizangia, Sinoleontopodium, Sindoxa,* and *Tetradoxa*) have been discovered (Myers, 1988).

4.7.2 Western Ghats

Of India's 49,219 plant species, 1600 endemics (40% of the total number of endemics) are found in a 17,000 km^2 strip of forest along the seaward side of the Western Ghats in Maharashtra, Karnataka, Tamil Nadu, and Kerala (WCMC, 1992). Forest tracts up to 500 metres in elevation, comprising one-fifth of the entire forest expanse, are mostly evergreen, while those in the 500-1500 metres range are semi-evergreen. There are two main centres of diversity, the Agastyamalai Hills and the Silent Valley/New Amambalam Reserve basin (Myers, 1988).

Very little has been documented recently about the status of the forest cover, except that it seems to have declined between 1972 and 1985 at a rate paralleling that for India as a whole, which implies a loss of over 2.4% annually. If we extrapolate from 1986 to 1989, this means a total loss of almost 34% for 1972 to 1989. According to Myers et al, (2000), only 6.8% of the original extent of vegetation exists today. Still worse is the decline of the primary forest: the amount remaining seems to be no more than 8000 km^2. All but isolated pockets of original forest have been opened up by shifting cultivation, allowing a take-over by deciduous species and bamboo among other forms of 'degenerate' vegetation.

4.8 THREATS TO BIODIVERSITY

Extinction or elimination of a species is a natural process of evolution. In the geologic period the earth has experienced mass extinction. During evolution, species have died out and have been replaced by others. However, the rate of loss of species in geologic past has been a slow process, the process of extinction has become particularly fast in the recent years of human civilisation. In this century, the human impact has been so severe that thousands of species and varieties are becoming extinct annually. One of the estimates by the noted ecologist, E.O.

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Wilson puts the figure of extinction at 10,000 species per year or 27 per day! This startling figure raises an alarm regarding the serious threat to biodiversity.

India's biodiversity is one of the most significant in the world. However, this rich biodiversity of India is under severe threat owing to habitat destruction and over exploitation. The country has several problems such as overpopulation, large number of cattle heads, growing demand for land, energy and water supply. Unplanned developmental works and over exploitation of resources have made its living resources most vulnerable. The major causes and issues related to threat to biodiversity are discussed below:

4.8.1 Loss of Habitat

Destruction and loss of natural habitat is the single largent cause of biodiversity loss. Billions of hectares of forests and grasslands have been cleared over the past 10,000 years for conversion into agriculture land, pastures, and settlement area and development projects. These natural forests and grasslands were the natural homes of thousands of species which perished due to loss of their natural habitat. The wetlands are destroyed due to draining, filling and pollution thereby causing huge biodiversity loss. In India, several rare butterfly species are facing extinction with the uncannily swift habitat destruction of the Western Ghats.

4.8.2 Poaching

Illegal trade of wildlife products by killing prohibited endangered animal, i.e. poaching, is another threat to wildlife. Man has hunted for food. Commercially wild animals are hunted for their products such as skin, tusk, antlers, fur, meat, pharmaceutical perfumes, cosmetics and decoration purposes. Despite international ban on trade in products from endangered species of wildlife items like furs, hides, horns, tusk, live specimen and herbal products worth millions of dollars per year continues. The developing nations in Asia, Latin America and Africa are richest sources of biodiversity and have enormous wealth of wildlife. The rich countries in Europe and North America and some affluent countries in Asia like Japan, Taiwan and Hong Kong are the major importers of the wildlife products and wildlife itself. We can certainly help in preserving biodiversity by not purchasing fur coats, purses, bags or items made of crocodile skin or python skin.

4.8.3 Man-Wildlife Conflicts

Sometimes we come across conflicting situation when wildlife starts immense damage and danger to man and under such situation it becomes very difficult for the forest department to pacify the affected villagers and gain local support for wild-life conservation. The root causes of these conflicts are discussed below:

(a) Loss of habitats or shirking of forest cover.

(b) Ill, wear and injured animals have a tendency to attack man.

(c) Due to lack of food.

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(d) Due to electric wiring in fields, animal get injured, suffer in pain and turn violent.

(e) Due to settlement in wildlife corridors.

(f) Due to low compensation, the agonized farmers get revengeful and kill the wild animals.

Remedial measures to curb the conflict:

(a) By dealing tactfully with any imminent danger.

(b) By adequate crop, cattle and human life compensation.

(c) By providing solar powered fencing with electric wiring.

(d) By changing crop patter near forest borders.

(e) By adequate fooder, fruit and water supply for wild animal in forest zone.

4.8.4 Overexploitation of Resources

This is one of the main causes of the loss of not only economic species but also biological curiosities like the insectivores and primitive species and other texa needed for teaching of laboratory work. Commercial exploitation of wild plants has invariably meant its overuse and eventual destruction. This has been as true in case of Indian wild mango trees, which were turned into plywood as of the whales that were hunted for tallow, in the oceans.

4.8.5 Collection for Zoo and Research

Animals and plants are collected throughout the world for zoos and biological laboratories for study and research in science and medicine.

4.8.6 Introduction of Exotic Species

Native species are subjected to competition for food and space due to introduction of exotic species. For example, introduction of goats and rabbits in the Pacific and Indian region has resulted in destruction of habitats of several plants, birds and reptiles.

4.8.7 Control of Pests and Predators

Predator and pest control measures, generally kill predators that are a component of balanced ecosystem and may also indiscriminately poison non-target species.

4.8.8 Pollution

Pollution alters the natural habitat. Water pollution especially injurious to the biotic components of estuary and coastal ecosystem. Toxic wastes entering the water bodies disturb the food chain, and so to the aquatic ecosystem. Insecticides, pesticides, SO_2, NO_x, acid rain, ozone depletion and global warming too, affect adversely the plant and animal species. The impact of coastal pollution is also

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very important, it is seen that coral reefs are being threatened by pollution from industrialisation along the coast, oil transportation and offshore mining. Noise pollution is also the cause of wildlife extinction.

4.8.9 Deforestation

One of the main causes of wildlife loss is increasing population and resultant deforestation. Deforestation mainly results from population settlement, shifting cultivation, development projects, demand for fuel wood, demand of wood as material for many industries such as paper and pulp, match, plywood, furniture etc.

4.9 ENDANGERED SPECIES OF INDIA

A species is said to be ***extinct*** *when it is not seen in the wild for 50 years at a stretch* e.g. dodo, passenger pigeon. *A species is said to be in* ***vulnerable*** *category if its population is facing continuous decline due to overexploitation or habitat destruction.* Such species is still abundant but under a serious threat of becoming endangered if casual factors are not checked e.g., plants as Cupressus cashmeriana (Kashmir cypress) and animals as Antelope cervicapra. *Species those are not endangered or vulnerable at present, but are at a risk, are categorized as* ***rare*** *species*. These species are usually localised with in restricted area i.e. they are usually endemic. Sometimes they are thinly scattered over a more extensive area.

A species is said to be ***endangered*** *when its number has been reduced to a certain level or whose habitats have been drastically reduced and if such species is not protected and conserved, it is in immediate danger of extinction.* The International Union for Conservation of Nature and Natural Resources (IUCN) publishes the **Red Data Book** which includes the list of endangered species of plant and animals. The red data symbolises the warning signal for those species which are endangered and if not protected are likely to become extinct in near future. On the global level, the IUCN published **Red Data Book** in two volumes. **Red Data Book** is the name given to the book dealing with threatened plants or animals of any region. Many countries have prepared their own **Red Data Book.**

Its opposite, is the **Green Book** published by Botanical Survey of India (BSI) which lists rare plants growing in protected area like botanic gardens. Green Book consists of 100 rare plant species. The United Nation Environmental Programme (UNEP) has complied endangered species of the world under the title, 'Blue Book'.

In India, nearly 450 plant species, 150 mammals and 150 species of birds is estimated to be threatened and identified in the categories of endangered or rare while an unknown number of species of insects are endangered.

Few of the endangered reptiles, birds, mammals and plants are given below:

Reptiles	:	Gharial, green sea turtle, tortoise, python.
Birds	:	Great India bustard, peacock, pelican, great Indian hornbill, Siberian white crane.

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Animals : Indian wolf, red fox, sloth bear, red panda, tiger, leopard, striped hyena, Indian lion, golden cat, desert cat, dugong.

Plants : Sapria Himalayan, Uvaria Iurida, Nepenthes Khasiana, Pedicularis perroter, Piper longum, Sesamum indicum, Butea, a large number of species of orchids, medicinal plants and the sandal wood tree etc.

Dodo

Passenger Pigeon

Fig. 4.4 Extinct species of India

Cupressus Cashmeriana

Antelope Cervicapra

Fig. 4.5 Vulnerable species of India

Green Sea Turtle

Indian Python

Great Indian Burtard

Fig. 4.6 Endangered reptiles and animal species of India

Indian Peacock

Dugong

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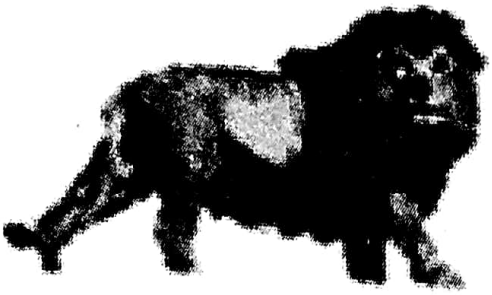
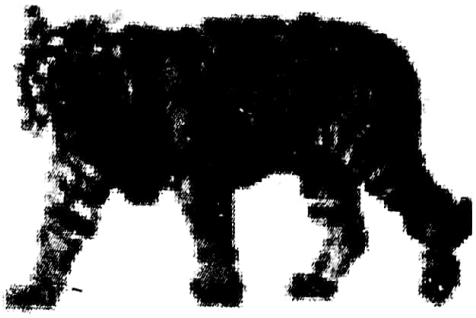


Lion



Tiger

Red Panda

Orchid

Piper longum

Fig. 4.7 Endangered Animal and plant species of India

4.10 ENDEMIC SPECIES OF INDIA

Total number of plant species recorded in the world is 2,50,000. In India 45,000 species, 33% of which are native. There are 15,000 flowering plant species which is 6% of the world's total. Areas rich in endemism are the Northeast, the Western Ghats and the Northwestern and Eastern Himalayas. Andaman and Nicobar Islands contribute at least 200 endemic species to the endemic flora.

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Table. 4.3 Endemic species of plants

Group	*No. of species*
Pteridophyta	200
Angiosperms	4950

Source: MoEF, 1999.

4.11 CONSERVATION OF BIODIVERSITY

In general, conservation of biodiversity refers to human efforts to correct, reverse, prevent or discontinue activities that are causing decline in biodiversity like pollution, deforestation etc. Conservation process performs the following functions:

- Maintenance of essential ecological processes and life-supporting system.
- Preservation of diversity of species.
- Suitable utilisation of species and ecosystem.

Gradually we are coming to realize that wildlife is not just 'a game to be hunted' rather it is a 'gift of nature' to be nurtured and enjoyed. A number of measures are now being taken the world over to conserve biodiversity including plants and wildlife. There are two approach of biodiversity conservation:

4.11.1 In-situ Conservation (Within Habitat)

Conservation of species in its natural residing place is known as in-situ conservation. It may be the natural ecosystem or the artificial one. This type of conservation is applicable only for wild fauna and flora and not to domestic animals. This is achieved by protection of wild flora and fauna in nature itself e.g. biosphere reserves, national park, wildlife sanctuaries, reserve forest etc.

At present we have 7 major biosphere reserves, 80 national parks and 420 wildlife sanctuaries in our country covering 4% of the geographic area.

The concept of biosphere reserve was started in 1975 under the 'Man and Biosphere' Pragramme of UNESCO. In this type, the multiple land use is permitted and the biosphere is not restricted to any one, two or more species but to the whole ecosystem. Thus, biosphere is ecosystem oriented. The biosphere reserves conserve some representative ecosystems as a whole for long-term in-situ conservation. Within a biosphere reserves we may have one or more national park. For example Nanda Devi (UP), Sunderbans (WB) and Nilgiri (which have Bandipur and Nagarhole National Park in it).

A national park is an area dedicated for the conservation of wildlife along with its environment. National parks are meant for the betterment of wildlife. It is also meant for enjoyment tourism but without impairing the environment. Grazing of domestic animals, all private rights and forestry activities are prohibited within national park. Corbett and Dudwa are the two examples of national park in Uttar Pradesh.

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Table 4.4 Biosphere reserves of India

Name of the site	*Date of notification*	*Area in sq km*	*Location (State)*
Nilgiri	01.08.86	5,520	Parr of Wynad, Nagarhole, Bandipur and Madumalai, Nilambur, Silent Valley and Siruvani hills (Tamil Nadu, Kerala and Karnataka)
Nanda Devi	18.01.88	5,860.69	Par of Chamoli, Pithoragarh, Almora Districts (Uttaranchal)
Nokrerk	01.09.88	820	Part of Gora Hills (Meghalaya)
Manas Wildlife Sanctuary	14.03.89	2,837	Part of Kokrajhar, Bongaigaon, Barpeta, Nalbari, Kamprup and Darang district (Assam)
Sunderbans	29.03.89	9,630	Part of delta of Ganga and Brahmaputra river system (West Bengal)
Gulf of Mannar	18.02.89	10,500	Indan part of Gulf of Mannar between India and Sri Lanka (Tamil Nadu)
Great Nicobar	06.01.89	885	Southern most islands of Andaman and Nicobar (A&N islands)
Similpal	21.06.94	4,374	Part of Mayurbhanj district (Orissa)
Dibru-Saikhowa	28.07.97	765	Part of Dibrugarh and Tinsukia district (Assam)
Dehang Debang	02.09.98	5,112	Part of Siang and Debang velley (Arunachal Pradesh)
Pachmarhi	03.03.99	4,926.28	Parts of Betul, Hoshangabad and Chindwara districts (Madhya Pradesh)
Kanchanjanga	07.02.00	2,619.92	Part of Kanchanjanga Hills (Sikkim)

Source: MoEF, 2000.

Table 4.5 India's World heritage sites

Site	Location
Kaziranga National Park	Assam
Keoladeo Ghana National Park	Rajasthan
Nanda Devi National Park	Uttar Pradesh
Sundarban National Park	West Bengal

Source: MoEF, 1999.

Wildlife sanctuaries are also protected area for wild lives where killing, hunting, shooting or capturing of wildlife is prohibited except under the control of highest authority. However private ownership rights are permissible and forestry operations are also permitted to an extent that they do not affect the wildlife adversely. Ghana Bird Sanctuary, Rajasthan (300 species of birds).

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4.11.2 Ex-situ Conservation (Outside Habitat)

Conservation of species away from their natural habitat is called ex-situ conservation. This is done by establishment of gene banks, seed banks, zoos, botanical garden, culture collection etc.

This type of conservation is mainly done for conservation of crop varieties with the main objective of conserving the total genetic variability of crop species for future improvement or afforestation programmes. Steps involved in ex-situ conservation:

(i) Establishment of minimum target population goals to provide for maintenance of captive genetic diversity.
(ii) Distribution of founders through various captive breeding programmes.
(iii) Circulation of compiled programmes to all breeding facilities.
(iv) Implementation of an overall plan contributing to the objectives of maintaining viable populations across the globe.

In India, we have the following important gene bank/seed bank facilities:

(a) National Bureau of Plant Genetic Resource (NBPGR), New Delhi.
(b) National Bureau of Animal Genetic Resource (NBAGR), Karnal, Haryana.
(c) National Facility for Plant Tissue Culture Repository (NFPTCR), New Delhi.

Advantages of ex-situ Conservation

1. Assurance of food, shelter and security to the organism.
2. Increase in life span and breeding activity.
3. Increase of chance of survival.
4. Possibility of use of genetic techniques to improve concerned species.

Disadvantages of ex-situ Conservation

1. It can be adopted only for a few species due to limitation of space, finance and facilities in the institution undertaking captive breeding.
2. Deprival of opportunity by organism to adopt to be ever-changing natural environment.

CASE STUDY

Project Tiger

Tiger sightings have become quite rare these days in India, reason being the tiger killings because of its multitude of medicinal or magical properties that is why tiger trade is very profitable. Genuinely the tiger skin is not fashionable but the smuggling of tiger fur coats and rugs are not difficult for the impoverished hunters.

In the beginning of the 1970s, once tiger hunting had officially been banned in India, a tiger count was done across the entire country. This lead to the shocking discovery that only 1800 specimens of this magnificent animal were

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left. This jolted the concerned authorities and some serious thought went into devising plans to save the tiger. The result was the launch of "Project Tiger" in 1972 on the 1st April at the Dhikala Forest Rest House in Corbett National Park. The main idea behind the project was to provide safe havens for tigers where they could flourish as a species and hopefully reverse the startling decline in their population. The project initially had 9 parks that were chosen for it's implementation. This number has slowly risen and a total of 19 parks are now attached to the project. The project was begun in association with and still receives its main funding from the WWF (World Wildlife Fund).

Some of the best examples of this programmes success can be seen in the national parks situated in the high Himalayan region, to the mangrove swamps of the Sunderbans and the thorny scrubs of Rajasthan. But more wildlife conservation laws and awareness among people is still required to make Indian sanctuaries a safe haven for tigers.

Tabel 4.6

Major Regions	Madhya Pradesh, Uttaranchal, West Bengal, Rajasthan, Kerala
Famous Tiger Reserves	Kanha National Park, Bandhavgarh National Park, Corbett National Park, Sunderbans National Park
Other Wildlife Attractions	Leopards, Antelopes, Deers, Sambar, Gaurs

Although the experts say that the project has its shortcomings, the increase in the populations of the tiger is clearly evident to even the common man. Many experts had predicted that the tiger would be extinct by the turn of the century, but, whoever may be responsible, the tiger has proudly proved them wrong. Tiger population may not still be in thrilling numbers and poaching still may be quite rampant but a lot more effort is being put into saving this beautiful animal. This is good news for the entire natural treasure of the country because if the tiger flourishes, so will the jungle and vice versa.

It's aims were:

- To ensure maintenance of a viable population of tigers in India for scientific, economic, aesthetic, cultural and ecological values.
- To preserve, for all times, areas of such biological importance as a national heritage for the benefit, education and enjoyment of the people.

Project Elephant

Project Elephant was launched in 1991-92 to assist states having ranging populations of wild elephants to ensure long-term survival of identified viable population of elephants in their natural habitats. States are being given financial as well as technical and scientific assistance in achieving the objectives of the project. Main activities of Project Elephants are as follows:

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- Ecological restoration of existing natural habitats and migratory routes of elephants;
- Development of scientific and planned management for conservation of elephant habitats and viable population of Wild Asiatic Elephants in India;
- Promotion of measures for mitigation of man elephant conflict in crucial habitats and moderating pressures of human and domestic stock activities in crucial elephant habitats;
- Strengthening of measures for protection of wild elephants form poachers and unnatural causes of death;
- Research on Project Elephant management related issues;
- Public education and awareness programmes;
- Eco-development;
- Veterinary care.

During the year an amount of Rs. 3.05 crore (approx.) was allocated to the elephant range states to enable them to provide financial assistance for habitat management of man-elephant conflict, payment of ex-gratia relief for loss of life etc., strengthening of anti-poaching measures, capture and translocation of problem elephant populations etc. Permission to capture 33 problem elephants in West Bengal and Assam was given in order to reduce man-elephant conflict. An amount of Rs. 142.30 lakh was released to the elephant range states to strengthen their anti-poaching and anti-depredation activities.

SUMMARY

Biodiversity is the verity and variability among living organisms from all sources and the ecological complexes in which they occur. Biodiversity is usually explored at three levels - genetic diversity, species diversity and ecosystem diversity. Genetic diversity refers to the variety of genetic information contained in all of the individual plants, animals and microorganisms. Species diversity is the variety of species within a habitat or a region. Ecosystem diversity encompasses the broad differences between ecosystem types, the diversity of habitats and ecological processes occurring within each ecosystem type.

India, being a vast country, shows a great diversity in climate, topography and geology and hence the country is very rich in terms of biological diversity. India is divided into 10 different classes on the basis of biogeography.

The values of biodiversity in terms of its commercial utility, ecological services, social and aesthetic value is enormous. The multiple uses of biodiversity or biodiversity value have been classified as Consumptive use value, Productive use value, Social value, Ethical value, Aesthetic value, Option values and Ecosystem service value.

Alpha (α-) diversity, Beta (β-) diversity and Gamma (γ-) diversity is a scale of measuring regional biodiversity. India is one of the 12 mega-diverse countries in the world because of its high endemism, centre of origin and marine diversity.

Hot spots are areas that are extremely rich in species, have high endemism, and are under constant threat. Among the 25 hot spots of the world, two are found in India the Western Ghats/Sri Lanka and the Indo-Burma region.

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The country has several problems such as overpopulation, large number of cattle heads, growing demand for land, energy and water supply, unplanned developmental works and over exploitation of resources causes the loss of biodiversity. The major causes and issues related to threat to biodiversity are loss of habitat, poaching, man-wildlife conflicts, over-exploitation of resources, collection of species for zoo and research, introduction of exotic species, control of pests and predators, pollution and deforestation.

Species which are restricted only to a particular area are known as **endemic** species. A species is said to be **extinct** when it is not seen in the wild for 50 years at a stretch e.g. dodo, passenger pigeon. A species is said to be in **vulnerable** category if its population is facing continuous decline due to over exploitation or habitat destruction. Species those are not endangered or vulnerable at present, but are at a risk, are categorized as **rare** species.

A species is said to be **endangered** when its number has been reduced to a certain level or whose habitats have been drastically reduced and if such species is not protected and conserved, it is in immediate danger of extinction. The International Union for Conservation of Nature and Natural Resources (IUCN) publishes the **Red Data Book** which includes the list of endangered species of plant and animals. The red data symbolizes the warning signal for those species which are endangered and if not protected are likely to become extinct in near future.

In general, conservation of biodiversity refers to human efforts to correct, reverse, prevent, or discontinue activities that are causing decline in biodiversity, like pollution, deforestation and chemical waste.

In-situ conservation (within habitat) is the conservation of species in its natural residing place. This is achieved by protection of wild flora and fauna in nature itself e.g. biosphere reserves, national park, wildlife sanctuaries, reserve forest etc. Ex-situ conservation (outside habitat) is the conservation of species away from their natural habitat is called ex-situ conservation. This is done by establishment of gene banks, seed banks, zoos, botanical garden, culture collection etc.

DESCRIPTIVE TYPE QUESTIONS

1. What is meant by 'Biodiversity'? What is its concept, describe the uses and importance of biodiversity. **[10 Marks](UPTU 2005)**
2. Explain the levels of biodiversity.
3. What is global and national biodiversity?
4. What is point, Alpha (α-) Beta (β-) and Gamma (γ-) richness? Discuss it with example.
5. What are hotspots of biodiversity? Name the hotspots found in India? Discuss it.
6. Write an explanatory note on threats to biodiversity. **[10 Marks](UPTU 2005)**
7. Is biotechnology a threat to biodiversity? Substantiate your answer with examples.
8. What are the endemic, extinct, endangered, vulnerable and rare species? Give example for each.
9. What is **'Red Data Book'**? How **'Red Data Book'** is different from **'Green Book'** and **'Blue Book'**?
10. Explain 'In-Site' and Ex-Situ' approaches of conservation of biodiversity. Compare their advantages and limitations. **[10 Marks](UPTU 2005)**
11. What is biodiversity? Explain genetic, species and ecosystem diversity. Explain the consumptive and productive value of biodiversity.

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12. What do you understand by 'Hotspots of Biodiversity'? Name and briefly describe, along with vital signs, the two hotspots of biodiversity that extend into India.
[10 Marks](UPTU 2006)

13. What do you mean by consumptive use value, productive use value, social value, ethical value and option value of biodiversity? **[10 Marks](UPTU 2006)**

14. Comment upon Indian biodiversity with special reference as a mega diverse nation.
[10 Marks](UPTU 2006)

15. What is '**Red Data Book**'? How do we declare species threatened or endangered? Name two species each of endangered reptiles, birds, mammals and plants of our country.
[10 Marks](UPTU 2006)

16. With the suitable examples explain how are poaching and human-wildlife conflicts responsible for biodiversity depletion?

17. India is a mega biodiversity region. Justify it.

18. Enumerate different biogeographic zones of India and explain the characteristic of each.
[10 Marks](UPTU 2006)

19. What is meant by 'biodiversity'? Explain the three levels of biodiversity and point out the major threats of biodiversity depiction.

SHORT QUESTIONS WITH ANSWERS

Q. 1. Define biodiversity.

Ans. Biological diversity or biodiversity refers to the variety of life forms: the different plants, animals and microorganisms, the genes they contain, and the ecosystems they form. It is defined as the variability among living organisms from all sources including, inter-alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part.

Q. 2. Enumerate the Biosphere Reserves of India.

Ans. At present India have 7 major biosphere reserves in country covering. In this type, the multiple land use is permitted and the biosphere is not restricted to any one, two or more species but to the whole ecosystem. Thus, biosphere is ecosystem oriented. The biosphere reserves conserve some representative ecosystems as a whole for long term in site conservation. Within a biosphere reserves we may have one or more national park. For example Nanda Devi (UP), Sunderbans (WB) and Nilgiri (which have Bandipur and Nagarhole National Park in it).

Q. 3. Expand IUCN, BSI and WWF.

Ans. IUCN – International Union for Conservation of Nature and Natural Resources
BSI — Botanical Servey of India
WWF — World Wide Fund

Q. 4. What is the main objective use of Red list?

Ans. **Red Data Book** includes the list of endangered species of plant and animals. The red data symbolizes the warning signal for those species which are endangered and if not protected are likely to become extinct in near future.

Q. 5. What is meant by man-animal conflicts?

Ans. Sometimes we come across conflicting situation when wildlife starts immense damage and danger to man and under such situation human being also start killing the wild animals it becomes very difficult for the forest department to pacify the affected villagers and gain local support for wildlife conservation, this conflicting situation is known as man-wildlife conflict.

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Q. 6. What are the roles of Biosphere reserves?

Ans. At present India have 7 major biosphere reserves in country covering. In this type, the multiple land use is permitted and the biosphere is not restricted to nay one, two or more species but to the whole ecosystem. Thus, biosphere is ecosystem oriented. The biosphere reserves conserve some representative ecosystems as a whole for long term in site conservation. Within a biosphere reserves we may have one or more national park. For example Nanda Devi (UP), Sunderbans (WB) and Nilgiri (which have Bandipur and Nagarhole National Park in it).

Q. 7. What are the ecosystem services which are provided by the biological diversity?

Ans. Ecosystem services which are provided by the biological diversity

(i) Provision of food, fuel and fibber
(ii) Provision of shelter and building materials
(iii) Purification of air and water
(iv) Detoxification and decomposition of wastes
(v) Stabilization and moderation of the Earth's climate
(vi) Moderation of floods, droughts, temperature extremes and the forces of wind
(vii) Generation and renewal of soil fertility, including nutrient cycling
(viii) Control of pests and diseases.

Q. 8. Name the plant which yield drug for (i) Malaria (ii) Cancer.

Ans. Quinine is a drug for malaria which is made from the bark of the Cinchona tree whereas Camptotheca acuminata is a member of the family Nyssaceae (tupelo family) and is native only to China and Tibet. Its primary anti-cancer ingredient is a quinoline alkaloid called camptothecin, which in turn has been modified to create a host of other anti-cancer drugs.

Q. 9. Define the following

(a) Exotic species
(b) Rear species
(c) Hot spots

Ans. Define the following:

(a) Exotic species is an organism that is not indigenous to a given place or area and instead has been accidentally or deliberately transported to this new location by human activity. Introduced species can often be damaging to the ecosystem it is introduced to. For example, introduction of goats and rabbits in the Pacific and Indian region has resulted in destruction of habitats of several plants, birds and reptiles.

(b) Species those are not endangered or vulnerable at present, but are at a risk, are categorized as **rare** species. These species are usually localized with in restricted area i.e. they are usually endemic. Some times they are thinly scattered over a more extensive area.

(c) **Hot spots** are areas that are extremely rich in species, have high endemism, and are under constant threat. The term was introduced by Mayer's (1988). The hot spots covering less than 2% of the world's land area are found to have 50% of terrestrial biodiversity. According to Mayer's et al (2000) an area is designated as a hot spot when it contains at least 0.5% of the plant species as endemic.

Q. 10. Differentiate between the

(a) National park and sanctuary
(b) In-situ and ex-situ conservation
(c) Species and genetic biodiversity
(d) Endangered and extinct species

Ans. Differentiate between

(a) A national park is an area dedicated for the conservation of wildlife along with its environment. It is also meant for enjoyment tourism but without impairing the environment. Grazing of domestic animals, all private rights and forestry activities are prohibited within national park. Wildlife sanctuaries are also protected area for wild lives where killing, hunting, shooting or capturing of wildlife is prohibited except under the control of highest authority. However private ownership rights are permissible and forestry operations are also permitted to an extent that they do not affect the wildlife adversely

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(b) Conservation of species in its natural residing place is known as in-situ conservation. It may be the natural ecosystem or the artificial one. This type of conservation is applicable only wild fauna and flora and not to domestic animals whereas conservation of species away from their natural habitat is called ex-situ conservation. This is done by establishment of gene banks, seed banks, zoos, botanical garden, culture collection etc.

(c) Genetic diversity refers to the variety of genetic information contained in all of the individual plants, animals and microorganisms. Genetic diversity is the variety of genes within a species while Species diversity is the variety of species within a habitat or a region. Some habitats, such as rainforests and coral reefs, have many species. Others, such as salt flats or a polluted stream, have fewer.

(d) A species is said to be **extinct** when it is not seen in the wild for 50 years at a stretch e.g. dodo, passenger pigeon. A species is said to be **endangered** (threatened species) when its number has been reduced to a certain level or whose habitats have been drastically reduced and if such species is not protected and conserved, it is in immediate danger of extinction.

Q. 11. Write short notes on **[10 Marks](UPTU 2006)**

(i) Rare species and Threatened species
(ii) Poaching of wild-life
(iii) In-situ conservation of biodiversity.

Ans. Short notes:

(i) Species those are not endangered or vulnerable at present, but are at a risk, are categorized as **rare** species. These species are usually localized with in restricted area i.e. they are usually endemic. Sometimes they are thinly scattered over a more extensive area and a species is said to be **threatened** (endangered species) when its number has been reduced to a certain level or whose habitats have been drastically reduced and if such species is not protected and conserved, it is in immediate danger of extinction.

(ii) Illegal trade of wildlife products by killing prohibited endangered animal i.e. poaching is another threat to wildlife. Man has hunted for food. Commercially wild animals are hunted for their products such as skin, tusk, antlers, fur, meat, pharmaceutical perfumes, cosmetics and decoration purposes. Despite international ban on trade in products from endangered species of wildlife items like furs, hides, horns, tusk, live specimen and herbal products worth millions of dollars per year continues.

(iii) Conservation of species in its natural residing place is known as in-situ conservation. It may be the natural ecosystem or the artificial one. This type of conservation is applicable only wild fauna and flora and not to domestic animals. This is done in national parks, wildlife sanctuaries, biosphere reserves and reserve forests.

MULTIPLE CHOICE QUESTIONS

1. Genetic variation between distinct populations of the same species is known as
(a) Species diversity. (b) Ecosystem diversity.
(c) Genetic diversity. (d) Biodiversity.

2. Which of the following is an endemic species of India?
(a) Asian elephant (b) Lion-tailed macaque
(c) Whales (d) Panda

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

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

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5. Who introduced the concept of biodiversity hotspot?
   (a) Christopher Columbus (b) Norman Myers
   (c) WWF (d) Charles Darwin
6. Lion-tailed macaque is found in
   (a) Western Ghats (b) Eastern Ghats
   (c) Caucasus (d) Western Himalaya
7. Which of the following is a cause of loss of biodiversity?
   (a) Habitat degradation and loss (b) Invasion of non-native species
   (c) Pollution (d) All of the above
8. The animal that has recently become extinct is
   (a) Dinosaur (b) Dodo
   (c) Wolly Mammonth (d) Archaeopteryx
9. The Dodo was extinct due to
   (a) Pollution (b) Invasion of non-native species
   (c) Over-exploitation of resources (d) Global environmental change
10. Indian bustard has become endangered species due to
   (a) Deforestation in Rajasthan (b) Spread of desert
   (c) Hunting (d) Change in climate
11. Which group of vertebrates comprises the highest number of endangered species?
   (a) Birds (b) Mammals
   (c) Fishes (d) Reptiles
12. Spot the site, which is not a biodiversity hotspot
   (a) Brazil's Cerrado (b) Central Chile
   (c) California Floristic Province (d) Pakistan
13. The area reserved for the welfare of wildlife is called
   (a) National Park (b) Forest
   (c) Botanical garden (d) Sanctuary
14. Kaziranga National Park is famous for
   (a) Rhinoceros (b) Tiger
   (c) Elephant (d) Musk deer
15. Animals and Plants are best protected
   (a) Zoos (b) Botanical garden
   (c) National Park (d) Sanctuaries
16. New approach to conservation is the establishment of
   (a) Biosphere Reserve (b) Reserve forest
   (c) National Park (d) Sanctuaries

Make the Statement True or False

(a) National parks are reserved for the conservation of animals only.
(b) Extinction of species refers to its disappearance from the earth.
(c) There are 13 biosphere reserves.

Match the Following Terms

Match the following terms of column I with appropriate terms of column II

Column I	Column II
(i) Doda	(a) In-situ conservation
(ii) Red data book	(b) Threat to biodiversity
(iii) National park	(c) Extinct species
(iv) Seed bank	(d) Endangered species
(v) Poaching	(e) Ex-situ conservation

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Fill in the Blanks

1. Biodiversity refers to the totality of ....., ... and ..... of a region.
2. Within a communi ty the diversity is called .....
3. Exotic species have large impact especially in ..... ecosystem.
4. Between community diversity is called .....
5. ..... and ..... In India are among the 25 global biodiversity hot spot.
6. As of September 2002, India had .....protected areas.

ANSWERS

Multiple Choice Questions

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

True and False

(a) False **(b)** True **(c)** True

Match the Following Terms

(i) c (ii) d (iii) a (iv) e (v) d

Fill in the Blanks

1. genes, species; ecosystem
2. alpha diversity
3. island
4. beta
5. Eastern Himalayan; & Wastern Chats
6. 581

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5 Chapter

Environmental Pollution

Inside This Chapter

5.1 Pollution
5.2 Air Pollution
5.3 Water Pollution
5.4 Soil Pollution
5.5 Marine Pollution
5.6 Noise Pollution
5.7 Thermal Pollution
5.8 Nuclear Hazard
5.9 Case Studies
5.10 Solid Waste Management
5.11 Role of Individual in Prevention of Pollution
5.12 Disaster Management

5.1 POLLUTION

The environment is made up of air, water and land, technically known as atmosphere, hydrosphere and lithosphere respectively, which together constitute the biosphere. In the biosphere, apart from human beings, plants, animals, birds, fishes, insects and microorganisms (algae, bacteria and virus) also exist. The atmosphere provides oxygen, while the hydrosphere and lithosphere provide food, water and space. Whenever a change, physical or chemical, occurs in the atmosphere, hydrosphere or lithosphere, all living beings are affected. This change is termed as pollution and the agents that institute these changes are called pollutants.

Pollution can be defined as an undesirable change in the physical, chemical or biological characteristics of our air, water or land that may or will harmfully affect the life or create a potential health hazard and threaten the survival or activities of humans or other living organisms.

Pollution is thus direct or indirect change in any environmental components that is adversely affecting the industrial progress, culture or natural assets or general environment.

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It is difficult to estimate the desirable and undesirable effects of any activity which alters the environment. Sometimes short-term gains can cause immeasurable damage in the future, as seen in the case of use of nuclear energy, motorcars, air-conditioners and refrigerators, etc. In an age of fast material change, pollution is an unavoidable result. History has shown that societies pollute first and pay later. As the decline of the biosphere continues unchecked, people must find the will to force governments and industries to change existing conditions.

5.1.1 Types of Pollutants

Environmental pollution may be defined as the inorganic, organic, radioactive or biological substances, noise, odour etc. which tends to damage the quality of the environment so as to constitute a hazard or impair the usefulness of the environment.

On the basis of **decomposition nature**, pollutants are of following two types:

Non-degradable pollutants: They include many radioactive materials, heavy metals and some plastics which cannot be degraded by natural or artificial means. They are not cycled in ecosystem naturally. They do not only accumulate but are often biologically magnified with their subsequent movement in food chains and biogeochemical cycles. They must be controlled or prevented from reaching the environment.

Degradable pollutants: Degradable pollutants are those that can be decomposed, removed or consumed or reduced to acceptable levels either by natural or artificial means. However, pollutants such as human sewage and animal and crop wastes can decompose only if the system is not overloaded. Certain chemicals decompose slowly, and can persist at harmful levels for decades like detergents and pesticides.

On the basis of **nature**, the pollutants are of following three types:

Physical pollutants: Heat, noise, radioactive substances, etc.

Chemical pollutants: Oxides of carbon, oxides of sulphur, oxides of nitrogen, halogen gases etc.

Biological pollutants: Microorganisms such as bacteria, virus and fungi etc.

On the basis of their **source of origin**, these are divided in following three types:

Point source pollutants: When the emission or origin source is point, i.e. the area are very less as compare to the environment. It includes emissions from stack.

Line source pollutants: When the emission source is in the form of line or curve e.g. transportation of material by conveyor belts, road rollers and run-off seepage etc.

Area source pollutants: When the emission or origin source is an area, i.e. the area is large e.g. crushing, grinding and blasting in mines etc.

5.2 AIR POLLUTION

Clean air, which is essential for the survival of all living organisms, is rapidly becoming scarce. At mean sea levels air contains 20.94% oxygen and 78.09% nitrogen. Other elements present comprise less than one percent of its composition.

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Air pollution may be defines as the presence of one or more contaminants in the atmosphere in such a quantity and of such duration as is or tends to be injurious to human health of welfare, animal or plants or properties or would unreasonable interfere with enjoyment of life and property.

5.2.1 Air Pollutants

Primary pollutants are those which are emitted directly into the atmosphere, like sulphur dioxide, nitric oxides and carbon monoxide. They are categorised as follows:

1. **Particulate matter (Aerosol):** Any kind of small particle found floating in the air is referred to as aerosols or particulates. Particulates in air are the result of both natural and human activities. Various types of particulate present in air are given below:
   (a) *Dust:* The particulates having the size 1 μm to 200 μm in solid forms is referred as dust. This includes metallic and non-metallic dust. Copper, lead, steel, aluminium zinc are examples of metallic dust while non-metallic industrial operations produce cotton dust, cement dust, asbestos dust, ceramic dust etc.
   (b) *Smoke:* It mostly consists of soot, fly ash and other liquid or solid particles 0.01 to 1 μm in diameter. Smoke arises from several sources such as factories, automobiles, oil refineries, steel plant etc.
   (c) *Fog:* Is special type of thin cloud consisting of microscopically small water droplets which are kept in suspension in the air near the ground surface.
   (d) *Smog (smoke + fog):* Smog is two types—one is found in place having coal as the principal fuel. The other one is photochemical smog.
2. **Oxides of carbon:** CO_2 and CO are the two important pollutants.
   (a) *Carbon monoxide:* CO, a product of incomplete combustion, is a deadly poisonous gas in high concentration. The chief sources are automobile, furnaces, domestic fires, forest fires, burning of coal in factories, houses and power plants.
   (b) *Carbon dioxide:* A large amount of CO_2 is released in the atmosphere from burning of fossil fuels. Domestic and thermal power plant furnaces, industries are the main sources of CO_2 emission.
3. **Oxides of nitrogen (NO_x):** Nitrous oxide (N_2O), nitrogen oxide (NO), nitrogen dioxide (NO_2), di-nitro trioxide (N_2O_3), di-nitro tetraoxide (N_2O_4), di-nitro pentaoxide (N_2O_5) and nitrogen trioxide (NO_3) collectively called as oxides of nitrogen. Of these seven oxides NO and NO_2 are the most important air pollutants. NO formed during lighting discharges and stratospheric oxidation of ammonia. A small amount of NO and N_2O are also emitted out of the soil through denitrification process by bacterial activity.

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4. **Oxides of sulphur (SO_x):** Sulphur dioxide, hydrogen sulphide and sulphate particles are the three forms of sulphur found in the atmosphere. The chief source of SO_2 emission are burning of fossil fuels as coal in thermal power plant, smelting of sulphur containing ore and other chemical industries related to fertilizer and sulphuric acid. The chief source of H_2S is decomposition of vegetation and animal waste especially in aquatic habitats. Coal pits, volcanic eruption, sulphur springs and sewage system are also give rise to not a little but considerable amount of hydrogen sulphide.
5. **Hydrocarbons**: There are many hydrocarbons known to be present in atmosphere as primary pollutants. They basically include methane, ethane, toluene, n-butane, iso-bentane, acetylene etc. coming out from automobile industrial exhaust and decomposition process.
6. **Halogens:** Halogen remains in the atmosphere in two forms, namely chlorine and fluorine. The chief source of Cl_2 is caustic soda industries. Motor vehicle exhaust contains lead halid aerosols and their photochemical decomposition releases chlorine atoms. Fluorine which is an essential element of protoplasm, becomes pollutant at high concentration. It occurs mainly in smoke form brick kiln and iron and steel industries.

Secondary pollutants are pollutants formed by the photochemical reaction of primary pollutants. For example, "smog", is a combination of smoke and fog. Smoke consists of carbon particles and fog is an emulsion of water vapour in air. Smog has become very common in large cities, especially during winter. Similarly acid rain is formed by the combination of sulphur dioxide and water vapour present in the air.

5.2.2 Sources of Air Pollution

Air pollution can be due to natural or man-made causes. The former is beyond our control as natural disasters like dust storms, earthquakes and volcanic eruptions throw up large quantities of dust and gases into the atmosphere. Man-made causes, however, should be prevented or controlled as they pose a greater danger by way of toxic emissions from factories, power plants, vehicular traffic, etc. Industries such as mining, thermal plants, brick kilns, etc. also pollute the air. These emissions are particularly intense in urban conglomerations where the density of human habitation is very high.

Natural sources: Volcanic eruption, forest fires, bio-pollutants etc.

Man-made sources:

- Burning of fossil fuels
- Automobiles
- Steel plants
- Thermal power plants
- Textile industries
- Fertilizer industries

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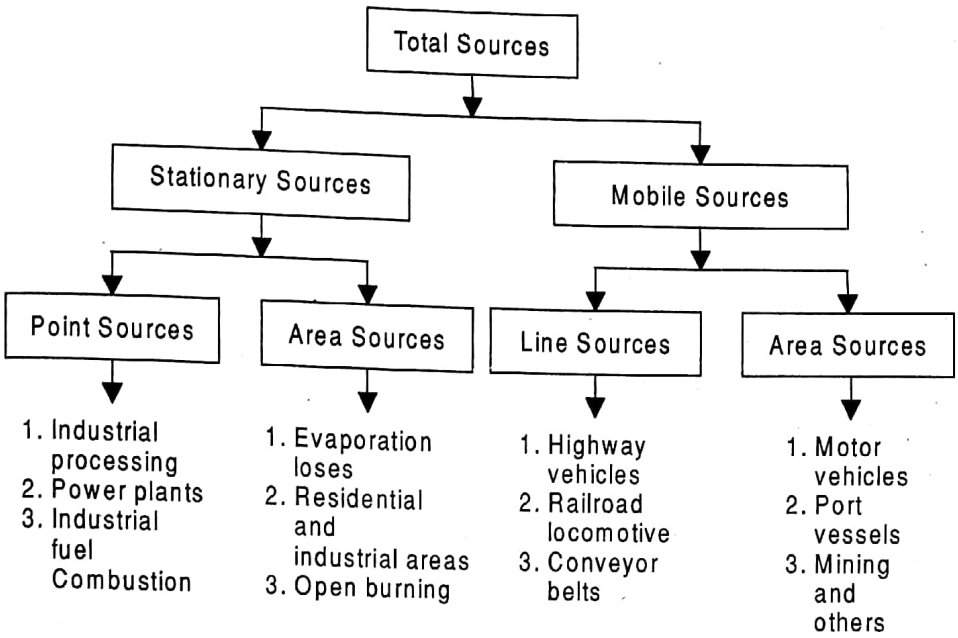

Fig. 5.1 Classification of Air Pollution Sources

5.2.3 Effects of Major Air Pollutants on Environment and Human Health

Most air pollutants do not lead to specific diseases. Depending on the pollutant, the concentration and the duration of exposure, some organs are more affected than others. The most frequent disorders are those caused by irritant gases and particulates on the mucous membranes and respiratory organs. The consequences are eye, nose and throat inflammations, diminished lung function, increased susceptibility to respiratory infection and a higher incidence of chronic bronchitis. These disorders and diseases are, of course, influenced by other factors as well, such as immune deficiency, allergies, occupational exposure to pollutants, and particularly smoking.

Other Effects of Air Pollution

1. Ozone causes reduced pollination and yellow spot formation on leaves, thus affecting the rate of photosynthesis and decreases in plant productivity.
2. Causes global warming (greenhouse effect), acid rain and helps in the formation of photochemical smog.
3. Causes chlorsis, nacrosis and epinesty in plants

Nacrosis	:	Killing or collapse of tissues
Chlorosis	:	Reduction in the chlorophyll
Abcission	:	Dropping of leaves
Epinasty	:	Downward curvature of the leaf due to higher rate of growth on the upper surface

4. Sulphur dioxide is converted to sulphuric acid in the presence of moisture and iron, which are present in dust, nails, etc. This results in yellowing, decolonisation, weakening and corrosion of materials and other physical distortion of building materials, monuments, status etc.

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5. Causes depletion of ozone in stratosphere.
6. Causing temperature inversion.

Major Air Pollutants, their origin and effects are given below:

TABLE 5.1

Pollutant	*Origin of Pollutant*	*Effects*
Sulphur dioxide	Industries, especially where coal or oil are used as fuel	Irritation of eyes, and respiratory system, increased mucus production, cough and shortness of breath
Carbon monoxide	Automobile exhaust and industries	Reduction in oxygen-carrying capacity of blood
Oxides of nitrogen	Automobile exhaust	Irritation of pulmonary tract affecting functioning of lungs
Hydrocarbons	Automobile exhaust	Lung cancer
Chlorine	Chloralkali industry	Irritation of mucous membrane
Ammonia	Fertiliser, industry, agriculture and in poultry farming	Irritation of mucous membrane
Hydrogen sulphide	Manufacture of coke, viscose rayon, distillation of tar and petroleum	Excessive inhalation leads to death
Acids and aldehydes	Chemical industries	Eyes, nose and throat irritation
Suspended particulate matter (SPM)	Industries, automobile exhaust	Respiratory diseases
Dust	Industries and automobile exhaust	Silicosis
Asbestos	Roofings, brake linings	Asbestosis
Lead	Automobile exhaust	Cumulative poison, impairment of central nervous system
Manganese	Mining operations	Damages nerves and reproductive system
Benzene	Automobile exhaust and manufacture of chemicals	Leukemia, chromosomal damage
Pesticides	Manufacture and application of pesticides	Depression; leads to death if inhaled in excess

5.2.4 Lapse Rate and Temperature Inversion

The degree of stability of the atmosphere depends on the rate of change of ambient temperature with altitude. **The decrease in temperature with altitude is known as lapse rate.**

Based on meteorological data in the troposphere up to 10 km, where the temperature decreases linearly with altitude, the environmental lapse rate is found to be about – 6.5°C/km.

The adiabatic decrease in temperature with altitude is especially important in the vertical movement of air pollutants. As the air rises in the atmosphere, it passes through a region of decreasing pressure and expands to equalise the decreasing

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pressure. As it expands, it does work on the surroundings. Since the process is usually rapid, there is no heat transfer between air parcel and the surrounding air, the gas undergo adiabatic cooling. The temperature lapse rate for dry air parcel moving upward adiabatically is known as dry adiabatic lapse rate and has been calculated to be nearly – 10° C/km for dry air and for humid air that is – 6° to –7°C/km.

A comparison of the adiabatic lapse rate with the environmental lapse rate gives an idea of the stability of the atmosphere. We now consider the following situations from the point of view of air pollution:

When the environmental lapse rate and the dry adiabatic lapse rate are exactly same and air would experience no buoyant force, such an atmosphere is said to be **neutrally stable.**

When the environmental lapse rate is greater than the dry adiabatic lapse rate, the atmosphere is said to be *super-adiabatic*. Then the atmosphere is said to be in an **unstable equilibrium**. Under these conditions the atmospheric pollutants are quickly dispersed due to considerable vertical mixing of air.

When the environmental lapse rate is less than the dry adiabatic lapse rate, such a condition is called **stable** and the lapse rate is said to be *sub-adiabatic*. The extreme case of a stable atmosphere occurs when the temperature increases with altitude, called an **inversion**. This occurs in the atmosphere due to the following reasons:

1. **Subsidence inversion**: This is usually associated with subtropical anticyclone where the air is warmed by compression as it descends in a higher pressure system and achieves temperature higher than that of the air underneath. If the temperature increase is sufficient, an inversion will result.
2. **Radiation inversion**: This result from the normal diurnal cooling cycle. After sunset, the ground cools quickly by radiational heat transfer, and the lowest layer of air in contact with surface loses sensible heat through conduction and small scale mixing. Consequently, a temperature inversion is set up between the cool low-level air and the warmer air above, in the first few hundred metres above the surface.
3. **Advection inversion**: This is formed when warm air moves over a cold surface or cold air. An example of an elevated advection inversion occurs when a hill range forces a warm land breeze to flow at high levels and a cool sea breeze flows at low levels in the opposite direction.

5.2.5 Control of Air Pollution

Air pollution can be controlled by two fundamental approaches: prevention techniques and emission control. They are as following:

1. The particulate matter can be removed by gravitational settling chamber, cyclone separator, fabric filter, electrostatic precipitator and wet scrubber.
2. The gaseous pollutants are controlled through absorption in liquid, adsorption on a solid surface and chemical alteration of the pollutants through combustion or catalytic treatment.

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3. By using desulphurised fuel.
4. By absorbing the toxic or pollutants gases in different solutions.
5. By plantation and foresting.
6. NO_x can be control by using excess amount of air.
7. Building higher smoke stack facilities, so that the discharge of pollutants is as far away from the ground as possible.

5.2.6 Air Pollution Control Equipment

The most common control technologies employed for particulates include the following:

- Gravitational settling chamber,
- Cyclone separator,
- Fabric filter,
- Electrostatic precipitator,
- Wet scrubber.

The first two are used for coarser particulates while last three are for finer.

Gravitational settling chamber: They are generally used to remove large, abrasive particles (usually > 50 μm) from gas streams. Since most of the troublesome particles have much smaller size than 50 μm, there devices are usually used as per cleaners prior to passing the gas stream through high efficiency collection device.

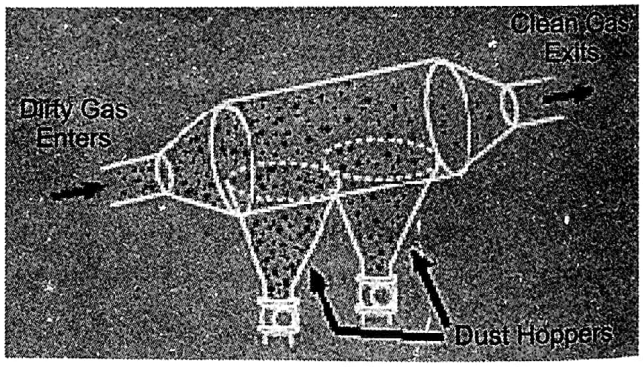

Fig. 5.2

Settling chambers, which rely on gravitational settling as a collection mechanism, are the simplest and oldest mechanical collectors. Settling chambers are generally built in the form of long, horizontal, rectangular chambers with an inlet at one end and an exit at the side or top of the opposite end. Flow within the chamber must be uniform and without any macroscopic mixing. Hoppers are used to collect the settled-out material, though drag scrapers and screw conveyers have also been employed. The dust removal system must be sealed to prevent air from leaking into the chamber which increases turbulence, causes dust re-entrainment, and prevents dust from being properly discharged from the device.

There are two primary types of settling chambers: the expansion chamber and the multiple-tray chamber. In the expansion chamber, the velocity of the gas stream is significantly reduced as the gas expands in a large chamber. The reduction in velocity allows larger particles to settle out of the gas stream.

A multiple-tray settling chamber is an expansion chamber with a number of thin trays closely spaced within the chamber, which causes the gas to flow horizon-

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tally between them. While the gas velocity is increased slightly in a multiple-tray chamber, when compared to a simple expansion chamber, the collection efficiency generally improves because the particles have a much shorter distance to fall before they are collected. Multiple-tray settling chambers have lower volume requirements than expansion-type settling chambers for the collection of small particles.

The efficiency of settling chambers increases with residence time of the waste gas in the chamber. Because of this, settling chambers are often operated at the lowest possible gas velocities. In reality, the gas velocity must be low enough to prevent dust form becoming re-entrained, but not so low that the chamber becomes unreasonably large. The size of the unit is generally driven by the desired gas velocity within the unit, which should be less than 3 m/s (10 ft/sec), and preferably less than 0.3 m/s (1 ft/sec).

Advantages of settling chambers include

1. Low capital cost;
2. Very low energy cost;
3. No moving parts, therefore, few maintenance requirements and low operating costs;
4. Excellent reliability;
5. Low pressure drop through device;
6. Device not subject to abrasion due to low gas velocity;
7. Provide incidental cooling of gas stream;
8. Temperature and pressure limitations are only dependent on the materials of construction; and
9. Dry collection and disposal.

Disadvantages of settling chambers include

1. Relatively low particulate matter collection efficiencies, particularly for particulate matter less than 50 μm in size;
2. Unable to handle sticky or tacky materials;
3. Large physical size; and
4. Trays in multiple-tray settling chamber may warp during high-temperature operations.

Cyclone separator: A cyclone separator is a very useful piece of equipment for the removal from air streams of particles above 10 micrometer in diameter. The equipment is a settling chamber in the form of a vertical cylinder, so arranged that the particle laden air spirals round the cylinder to create centrifugal forces which throw the particles to the outside walls.

The gas or liquid stream is injected at high velocities through the inlet pipe, which is positioned tangentially to the body of the cyclone (Seinfeld, 1975). The shape of the cone induces the stream to spin, creating a vortex. Larger or denser particles are forced outward to the walls of the cyclone where the drag of the spinning air as well as the force of gravity causes them to fall down the sides of the cone into an outlet (Seinfeld, 1975; Svarovsky, 1984). Meanwhile the lighter and/or less

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dense particles as well as the gas or liquid medium exit through the top of the cyclone via the low pressure centre.

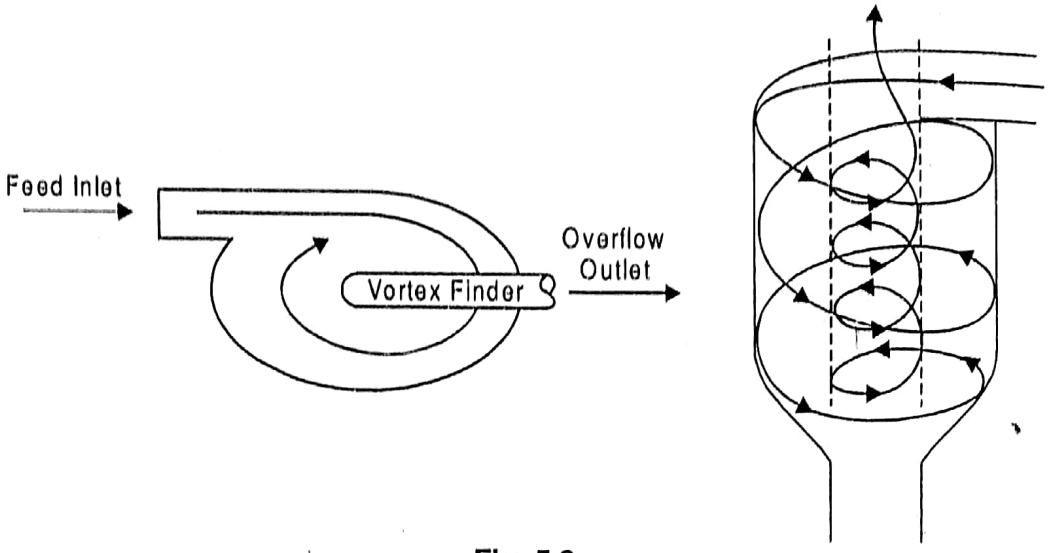

Fig. 5.3

The separation process in cyclones requires a steady flow, free of fluctuations or short term variations in the flow rate. Cyclone separators are customarily operated with the top and bottom open to the atmosphere so that there is no pressure difference between the two (Singh and Eckhoff, 1995).

Electrostatic precipitator: The electrostatic precipitator has two electrodes: discharge electrode and collecting electrode. When smoke containing particulates is ionized while passing between the discharge electrode (which induces corona discharges) and the collecting electrode, the particulates are negatively charged. Attracted by positive electricity, the particulates then adhere to the collecting electrode. Accumulated particulates, periodically hammered, fall to the bottom of the precipitator and are removed.

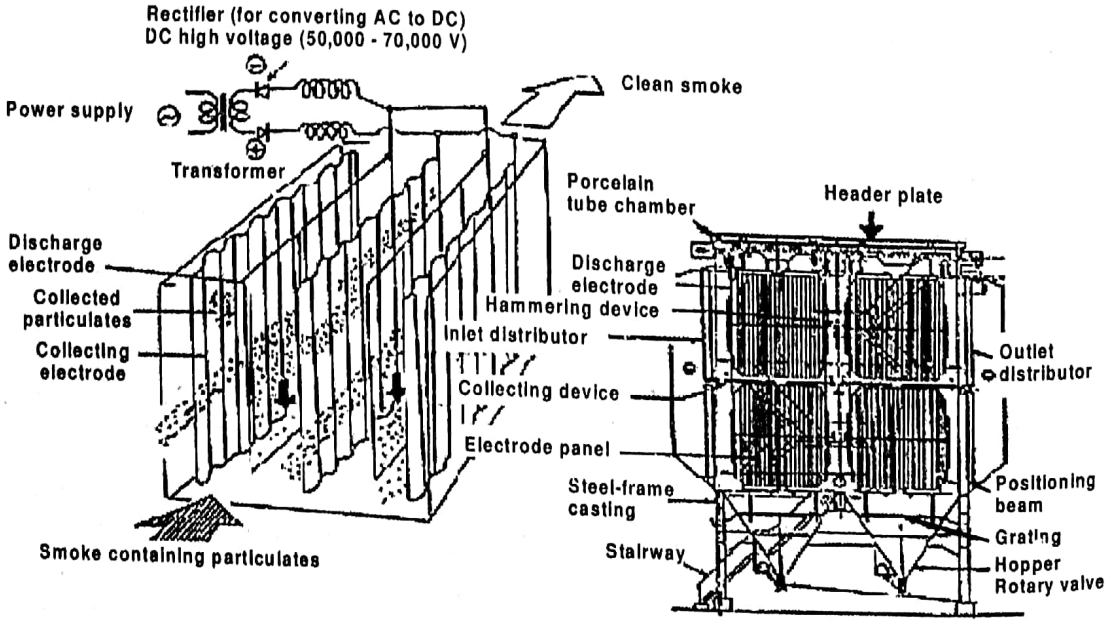

Fig. 5.4

The main applications of ESP are in textile, pulp and paper, coke ovens in steel industry, hog fuel boilers, veneer and particle board dryers, glass furnaces, stannic

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chloride collection, SO_2 control, fly ash control, pharmaceutical detergent dryers, cogeneration, distilling liquors and beers, phosphorus furnace emissions, silicon manufacturing, power plant emissions, ammonia removal, phosphate fertiliser manufacturing, phosphoric acid manufacturing, liquid waste incinerators, solid waste incinerators, corn drying, sulfuric acid plants, incineration of sewage sludge, rotary kiln cleaning, cement plants.

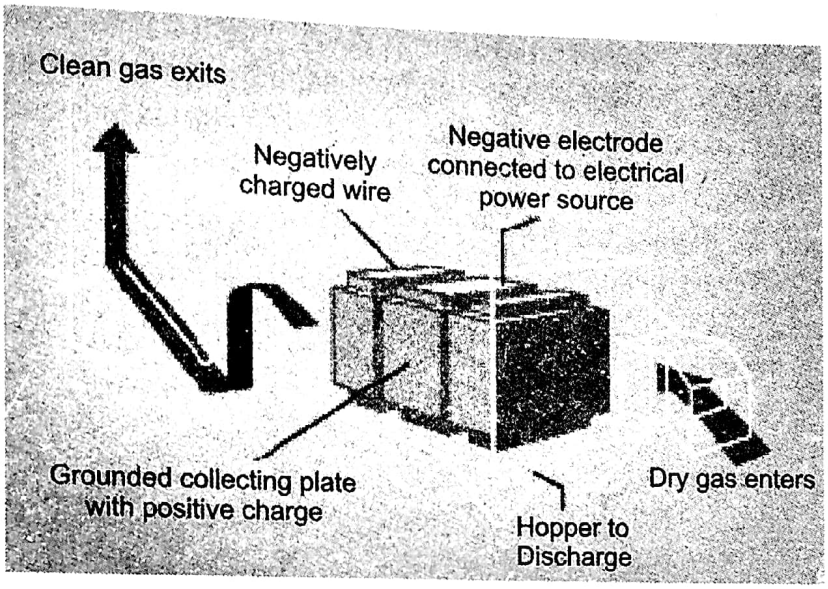

Fig. 5.5

Wet scrubber: Wetted packed towers are the simplest and most commonly used approaches to gas scrubbing. The principle of this type of scrubber is to remove contaminants from the gas stream by passing the stream through a packed structure which provides a large wetted surface area to induce intimate contact between the gas and the scrubbing liquor. The contaminant is absorbed into or reacted with the scrubbing liquor. The packing of the tower is normally a proprietary loose fill random packing designed to encourage dispersion of the liquid flow without tracking, to provide maximum contact area for the 'mass transfer' interaction and to offer minimal back pressure to the gas flow. The reactivity between the contaminant and the scrubbing liquor influences the system designer's determination of gas and liquor flow and the height and diameter of the packed bed.

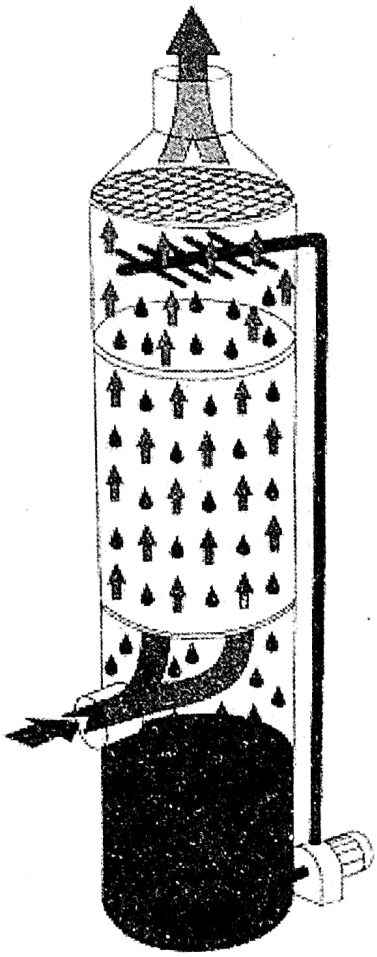

Fig. 5.6

Wetted packed towers can be designed for very high efficiencies with relatively low capital and running costs. The low pressure drop associated with packed bed scrubbers permits the use of smaller more economical fans. Although efficiency may be affected, a packed tower will usually function when gas or liquor flows vary from its original design parameters.

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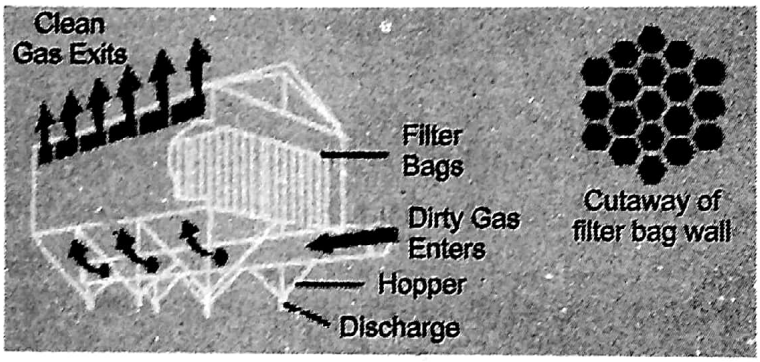
The major types are: spray tower (5-10 μm), centrifugal scrubber, packed bed and plate column, venture scrubber (> 3 μm).

Fabric filter: Filtration is the outlet and generally one of the most versatile and efficient method for removing particulate matter from industrial gases. Fabric filters are used to remove particles from a gas stream. Fabric filters are made of a woven or felted material in the shape of a cylindrical bag or a flat supported envelope. These elements are contained in a housing which has gas inlet and outlet connections, a dust collection hopper; and a cleaning mechanism for periodic removal of the collected dust from the fabric. In operation, dust laden gas flows through the filters, which remove the particles from the gas stream.

In principle, the dust-laden gas passes though a fabric in which the particles are trapped due to different physical mechanism. The important mechanisms by which the particles are separated from the gas stream are usually inertial impaction, direct interception and diffusion.



Source: http://www.epa.gov/

Fig. 5.7

Advantages and disadvantages

(a) Advantages

1. Very high collection efficiencies possible (99.9 + per cent) with a wide range of inlet grain loadings and particle size variations. Within certain limits fabric collectors have a constancy of static pressure and efficiency, for a wider range of particle sizes and concentrations than any other type of single dust collector.
2. Collection efficiency not affected by sulphur content of the combustion fuel as in ESPs.
3. Reduced sensitivity to particle size distribution.
4. No high voltage requirements.
5. Flammable dust may be collected.
6. Use of special fibers or filter aids enables submicron removal of smoke and fumes.
7. Collectors available in a wide range of configurations, sizes, and inlet and outlet locations.

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(b) *Disadvantages*

1. Fabric life may be substantially shortened in the presence of high acid or alkaline atmospheres, especially at elevated temperatures.
2. Maximum operating temperature is limited to 550° F, unless special fabrics are used.
3. Collection of hygroscopic materials or condensation of moisture can lead to fabric plugging, loss of cleaning efficiency, large pressure losses.
4. Certain dusts may require special fabric treatments to aid in reducing leakage or to assist in cake removal.
5. Fabric bags tend to burn or melt readily at temperature extremes.

5.3 WATER POLLUTION

Like clean air, fresh water is also becoming a scarcity. The limited availability of fresh water and its unequal distribution make water pollution a matter of great concern. Water pollution is generally localised and confined, making it more severe. The pollutants undergo many reactions and can become hazardous. 70% of India's fresh water is polluted, including several high altitude lakes. While water pollution is easier to study and manage, its control is highly complex and very costly.

Water pollution is defined as presence of any foreign substance (organic, inorganic, biological or radiological) in water which tends to degrade the quality so as to constitute a hazard, or impair the usefulness of water.

It contains various types of impurities such as dissolved gases, dissolved minerals and suspended matters and even microbes. The presence of water pollutants alters the amount dissolved oxygen and biochemical oxygen demand. **Dissolved oxygen (DO)** is the amount of oxygen present in the aquatic system that is available for aquatic life and is essential for sustaining the plant and animal life in any aquatic system. The **biochemical oxygen demand (BOD)** is a measure of the oxygen required by aerobic microorganisms to biochemically oxidize the organic matter present in the waste and is expressed in mg/l. Another quick measure of organic matter present in waste waste is **chemical oxygen demand (COD)** and in this case, chemical oxidants (potassium dichromate in acidic conditions) are used instand of aerobic mocroorganisms for the oxidation of organic matter. Generally COD of a waste will be higher than its BOD because more organic compound can be chemically oxidized than biochemically.

5.3.1 Types of Water Pollution

Natural water pollution: is caused by leaching of rocks, decaying of organic or dead matter, soil erosion, silting etc.

Man-made water pollution: is caused due to deforestation, industrial setup near water bodies, industrial waste, domestic sewage radioactive waste, synthetic chemicals, fertilizers, pesticides etc.

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5.3.2 Water Pollutants

Table 5.2

Categories	*Nature*	*Examples*
Physical	Temperature	Waste heat from industries
	Turbidity and colour	Dyes and pigments
	Suspended and floating matter	Sand, silt, metal pieces, plastic, rubber, wood chips, paper, foam sewage etc.
Chemical	Organic	Synthetic detergents, tars, plastic, fertilizers, organic effluent from industries etc.
	Inorganic	Nitrates, phosphates, chlorides, fluorides, trace elements etc.
Biological	Pathogenic	Bacteria, fungi, virus, worms etc.

5.3.3 Sources of Water Pollution

In underdeveloped countries, sewage is a major source of water pollution. Human excreta contain 400 different species of bacteria and viruses. Even well-treated sewage contains pathogenic bacteria and virus, unless properly chlorinated before being discharged into any water course. Sewage is a major contributor to water-borne diseases and affects the health of people and other organisms in the environment in many ways.

Industrial effluents from sugar factories, distilleries, tanneries and paper industry are accompanied by very high organic loads. By-products of paper and pulp industry cause depletion of fish up to as far as 40 km downstream. The wastes from oil refineries and steel industries contain phenol which imparts a strong odour, apart from poisoning the water body. Fertilizer industry wastes contain ammonia, urea, phosphate and sulphate which, in water, cause algal bloom and are toxic to aquatic fauna and flora. Alkaline industry wastes contain mercury which can kill human beings who consume mercerised fishes.

Lead generated from battery, printing, petrol and paste-processing industries, trace and toxic elements such as zinc, copper etc., and effluents from mining industries are injurious to aquatic organisms.

5.3.4 Effects of Water Pollution on Environment and Human Health

Other effects are:

- Objectionable odour;
- Increase in turbidity;
- Destruction in aesthetic value;
- Increase in temperature of water body;

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- Due to increase in turbidity of water, the rate of photosynthesis decrease in water bodies as aquatic plants don't get sufficient sunlight; and
- Due to run off water the nutrients reach the water body, which becomes nutrient rich (process is known as eutrophication), the rate of growth of aquatic plants increases very rapidly, the penetration of sunlight to the bottom of the water body in not possible and amount of dissolved oxygen decreases that effects aquatic life

Table 5.3 Major water pollutants and their effect on human health

Pollutant	*Origin*	*Effects*
Arsenic	Pesticide industries and agriculture	Toxic, eruptions on skin, carcinogenic
Chlorine	Industries using chlorine bleach	Physiological
Chromium	Industrial waste, especially from tanneries	Toxic and carcinogenic
Cyanide	Pesticides	Toxic and fatal
Lead	Industrial, mine discharges, water pipes	Causes a disease called plumbism
Nitrates and nitrites	Fertilizer industries	Cause metaemo globinaemia in infants
Mercury	Pesticides	Toxic, causes brain damage
Bacteria	Sewage	Cholera, typhoid, hepatitis, dysentery
Sulphates	Leaching of gypsum or industrial waste discharges	Have laxative effect in combination with magnesium or sodium in drinking water, may form hydrogen sulphide gorkers in sewers

5.3.5 Control of Water Pollution

The water pollution can be controlled by treating polluted water by removing the contaminants up to acceptable quality standards, so that water can be reused or discharged into water bodies. Available waste water treatment process can be broadly classified as physical, chemical or biological.

Physical processes are the simplest forms of treatment and are depends on the removal of physical pollutants and also known as primary treatment. They remove identifiable suspended solid and floating matter. These principally comprise screening, sedimentation, filtration and flotation.

In biological treatment, also known as secondary treatment, organic matter that is soluble or in the colloidal form is removed. Secondary treatment is done with the help of aerobic (works in the presence of oxygen) and anaerobic (works in the absence of oxygen) microorganism. Biological process utilizes biochemical reac-

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tions; typical examples are biological filtration (trickling filters), oxidation ponds and the activated sludge process.

Chemical processes utilise the chemical properties of the impurities or of the added reagents. Commonly used chemical processes are absorption, precipitation, coagulation and disinfection (the removal of nitrate and phosphate bacteria is carried out by passing chlorine/ozone gas).

Advance waste treatment may involve physical, chemical or biological processes or their various combinations depending on the impurities to be removed. These processes are employed to remove residual soluble non-biodegradable organic compounds, including surfactants, inorganic nutrients and salts, trace elements and dissolved inorganic salts. The advance waste treatment process are expensive and are used only when water produced is required to be of higher quality.

After these treatment stages, the water is clean to supply in household and discharge in water bodies. The sludge is the by-product of the treatment process and it can use in agriculture as manure.

Sewage treatment is done with the help of septic tank, which is an anaerobic suspended growth biological treatment system. They are made up of concrete and situated under the ground, having distributor box and porous rods. In septic tank anaerobic bacteria bio-chemically oxidize the organic matter. Septic tanks are usually adopted for small communities of population up to 300.

5.4 SOIL POLLUTION

Soil is the thin layer of organic and inorganic material that coverts the earth's rocky surface. Several factors contribute to the formation of soil from parent material. This includes the mechanical weathering of rocks due to temperature changes and abrasion, wind, moving water, glaciers, chemical weathering activities and lichens. The surface litter layer consists of freshly-fallen and partially decomposed leaves, twigs, animal waste, fungi and other organic materials are known as 'topsoil'.

Soil pollution is the introduction of substances, biological organisms or energy into the soil, resulting in a change of the soil quality, which is likely to affect the normal use of the soil or endangering public health and the living organism. Soil pollutants have an adverse effect on the physical, chemical and biological properties of soil and reduce its productivity.

Land is a very valuable but limited resource, as the population increases rapidly. Many highly urbanized cities are faced with acute space problems, as in Kolkata or Mumbai. Besides the limited availability of land, 175 million hectares of land are becoming less productive every year. India loses 20 tons of topsoil per hectare in a year due to floods, rainfall and deforestation. 20% to 50% of lands under irrigation can go out of cultivation at this rate because of water logging and salinity.

5.4.1 Causes of Soil Pollution

- Indiscriminate discharge and dumping of industrial effluents on land, thus contaminating them.

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- An increase in the use of pesticides and fertilizers for agriculture increases soil's toxicity
- Open defecation by animals and human beings.
- Accumulation of solid waste; this is a major problem in developing countries like India where the garbage and refuse products are not degraded.
- Radioactive substances from nuclear plants which are released into the soil. These substances when reach to the soil and persist there for a long time and keep on emitting radiation.
- Nitrification process where nitrates are leached out from the soil by plants in presence of nitrifying bacteria.
- Acid rain increases the normal pH of soil and converts neutral soil to acidic one.
- Soil erosion causes the loss of top soil and makes the soil less fertile and reduces its water holding capacity, hence productivity. It also contributes to water pollution by clogging lakes and increasing the turbidity of the water and ultimately leads the loss of aquatic life.
- Water logging and salinization increases the soluble salts in soil and makes the soil toxic.

5.4.2 Effects of Soil Pollution

- Effects human health.
- Reduces soil productivity.
- Decomposition of organic matter by microorganism releases unpleasant odour
- Contaminates groundwater.
- Radioactive isotopes replace the essential elements of body and causes abnormalities.

5.4.3 Control of Soil Pollution

- Effluents should be properly treated before discharging them on soil.
- Solid waste should be properly collected and disposed off by appropriate method.
- From the waste, recovery of useful products should be done.
- Biodegradable organic waste should be used for generation of biogas.
- Cattle dung should be used for methane generation.
- There should be optimum use of fertilizers and pesticides.
- By bioremediation. Bioremediation is a treatment process that uses micro organisms (yeast, fungi or bacteria) to breakdown or degrade hazardous substances into less toxic or non-toxic substances (carbon dioxide and water).

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5.5 MARINE POLLUTION

Marine pollution can be defined as the direct or indirect introduction of substances or energy into the marine environment (including estuarine), causing in harm to living resources, hazards to human health, hindrance to marine activities including fishing and impairment of the quality of sea water. A big problem is that many poisons and toxic components adhere to tiny particles which are taken up within a few days by aquatic plants and aquatic small animals, most of which concentrating upward within ocean food chains. Because most animal feeds contain high fish meal and fish oil content, toxins can be found a few weeks later in commonly consumed food items derived from livestock and animal husbandry such as meat, eggs, milk and butter.

5.5.1 Sources of Marine Pollution

1. Sewage, runoff from forestry, farming and other land use.
2. Erosion from mining and forestry.
3. Barges and ships also dump industrial waste, sludge from sewage plant and materials dredged or scraped from the bottoms of harbours and streams to maintain shipping channels into the ocean.
4. Rivers which bring pollutants from their drainage basin.
5. Catchment's area i.e. coastline where human settlement in the form of hotels, industries and agricultural practices have been established.
6. Crude petroleum and refined petroleum are accidentally or deliberately released into the environment from a number of sources.
7. Dumping of discarded radioactive waste and nuclear submarine.

5.5.2 Effects of Marine Pollution

1. Causes algal booms in coastal water.
2. Volatile organic hydrocarbons in oil immediately kill a number of aquatic organisms and oil coating destroy the animals' natural insulation and buoyancy.
3. Affects recreational facilities on the beaches.
4. Decrease in aesthetic value.
5. Causes radioactive radiation
6. Oil on beaches can have serious economic effects on coastal residents, who lose income from fishery and tourist activities.

5.5.3 Control of Marine Pollution

1. Toxic pollutants from industries and sewage treatment plants should not be discharged in coastal water.
2. Run-off from non-point sources (rivers) should be prevented to reach coastal area.

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3. Dumping of toxic, hazard and radioactive waste should be banned.
4. Developmental activities on coastal area should be minimized.
5. Oil and greases from service station should be processed for reuse.
6. By legal regulations.

5.6 NOISE POLLUTION

Sound is mechanical energy from vibrating source. **Noise can be defined as an unpleasant and unwanted sound and has become a part of urban life and industrial centre in this century.** Whenever a given sound is as pleasant as music or as unpleasant as noise depends on its duration, rhythm, loudness and mood of the person. Noise is a physical form of pollutant and is not directly harmful to the life supporting system namely air, water and soil. Its effects are more directly on the receiver i.e. man.

The noise measurements are expressed as sound pressure level (SPL) and increase in sound pressure does not invoke linear response of human ear. SPL is logarithmic ratio of the sound pressure to a reference pressure. It is expresses as a dimensional unit, decibel (dB). The decibel scale is logarithmic; each 10 decibel increase represents a tenfold increase in noise intensity. Human perception of loudness also conforms to a logarithmic scale; a 10 decibel increase is perceived as roughly a doubling of loudness. The central pollution control board (CPCB) committee has recommended permissible noise level for different locations:

Category of area	*Noise level in dB*	
	Day (6 AM – 9 PM)	*Night (9 PM – 6 AM)*
Industrial	75	70
Commercial	65	55
Residential	55	45
Sensitive	50	40

5.6.1 Sources of Noise Pollution

Noise pollution may come from loudspeakers, factories, aeroplanes, moving trains, construction activity or even a radio. The sources are categorized as follows:

1. **Industrial operation:** Textile mills, printing presses, metal works and engineering establishment.
2. **Transport vehicles**: Air, road and rail transportation.
3. **Household:** Electric home appliances, entertainment equipments, loud conversation and moving of furniture.
4. **Celebrations:** Social/religious functions, elections, demonstration and commercial advertising.
5. **Agricultural machines:** Tractors, thrashers, harvesters, tubewells.
6. **Construction:** Noise from construction equipments is a major source of noise pollution like mixers etc.

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7. **Defense equipment:** Artillery, tanks, launching of rockets, explosions, exercising of military airplanes, shooting practices, screams of jet engines and sonic booms.
8. **Miscellaneous sources:** Automobile repair shops, construction works, bulldozing, stone crushing, blasting etc.

5.6.2 Effects of Noise Pollution

Noise level of 80 decibels or more for more than 8 hours a day increases tension and changes in breathing patterns. Continued exposure of noise results high levels fatigue, temporary or permanent shift of the hearing threshold of a person (hearing loss or even total loss of hearing), changes in blood circulation, changes in breathing, etc. Noise pollution above 120 decibels can cause many adverse biochemical changes. Cholesterol levels in the blood and white cell counts increase, besides causing hypertension and chances of heart diseases. Other effects are:

1. Exposure to sufficiently intense noise for a long duration results in permanent damage to the delicate tympanic membrane or the ear drum.
2. Noise can also cause some physiological effects like headache by deleting blood vessels of the brain, cardiovascular and gastric effects.

Table 5.4

Noise Level in decibels	*Source*	*Psychological and physical effect*
135	Pneumatic drill	Painful
110	Rock band	Pneumatic drill
88	Industry/city traffic	Hearing impairment on prolonged exposure
80	Alarm clock	Annoying
65	Average city traffic	Intrusive

3. Muscular strain and nervous breakdown.
4. Noise can disturb sleep.
5. Noise pollution can have a considerable effect on communication.
6. Lack of concentration.
7. Efficiency of the person is reduced.
8. Noise affects the quality of life.

5.6.3 Control of Noise Pollution

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

At the source:

- Reduction in sources of noise.
- Proper oiling will reduce the noise from machinery.

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- Tightening the loose nuts.
- Decibel metres should be installed along highways and in factories to check and control the intensity of noise pollution.

In the path:

- A green-belt effectively reduces the noise.
- A 20 foot wide plantation inside the compound protects the house from the noise of vehicular traffic.
- Noise making machine should be kept in containers with sound absorbing media.
- Use of sound absorbing silencers.
- Through laws

At the receivers end:

If, by the above methods we are not able to bring down the noise level up to required levels the only alternative is to provide ear plugs while working or moving in a noisy area.

5.7 THERMAL POLLUTION

Thermal pollution can be define as presence of waste heat in the water which causes undesirable changes in the natural environment. It is the process of heating up a water body through discharge or run-off. Heat and hot water are in particular by-products of the activity of thermal power station. The warm water discharged into the marine system has harmful effects on marine animal life.

Thermal pollution is a very serious hazard to aquatic systems because the availability of dissolved oxygen (DO) is greatly reduced and this is detrimental to aquatic life. Moreover, the life cycle and natural processes of many aquatic life forms are so closely geared to water temperature that any artificial changes in temperature can completely disrupt the normal life pattern.

5.7.1 Causes of Thermal Pollution

- Industrial effluents and domestic sewage.
- Earthquake can be a source of thermal pollution.
- Dumping of radioactive waste in marine system increases its temperature when these substances radiate energy which break in their stable isotopes.
- Water temperature increases when the tress, those provide shade to the water bodies, are cut down.
- Power plants and heat producing industries i.e. refineries, steel mills etc. use large quantities of water for cooling purposes. Used coolant water is usually discharged into water bodies. This could result in increase in temperature of water bodies with deleterious consequences for aquatic inhabitants.

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5.7.2 Effects of Thermal Pollution

- An increase in water temperature decreases the oxygen saturation percentage and at the same time accelerates the lowering of dissolved oxygen and may lead to anaerobic conditions.
- Barrier for oxygen penetration into deep cold waters.
- As increase in temperature also increases toxicity of pesticides, detergents and chemical pollutants.
- The composition of flora and fauna changes.
- In addition to low DO levels, the metabolic activities of aquatic microorganism increases with temperature at a rate which approximately double for every 10°C increase in temperature.
- Discharge of heated water near the shores can kill young fishes.
- Fish mitigation is affected due to formation of various thermal zones.

5.7.3 Control of Thermal Pollution

The following methods can be employed for control of thermal pollution:

- **Cooling ponds:** Hot water is pumped into one end of the pond and cooler water is removed from the other end. The heat gets dissipated from the pond into the atmosphere.
- **Cooling towers:** These structures take up less land area than the ponds. Here most of the heat transfer occurs through evaporation. The warm water coming from the condenser is separated downwards over vertical sheets or baffles, where the water flows in thin films. Cool air enters the tower through the water inlet that encircles the base of the tower and rises upward, causing evaporative cooling. A natural draft is maintained because of the density difference between the cool air outside and the warmer air inside the tower. The excess heat is dissipated in to the atmosphere about 100 m above the base of the tower. The cooled water is collected at the floor of the tower and recycled back to the power plant condensers.

  (a) wet cooling tower

  (b) dry cooling tower
- Spray ponds

Some of the potential physical applications for thermal discharge (rejected heat) of power plants are

1. Industrial and space heating;
2. Biological applications such as soil warming; and
3. Fish culture, livestock shelter and for heating greenhouses.

Most of these potential physical applications are of colder region or locations.

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5.8 NUCLEAR HAZARD

Nuclear energy is energy that is let out during the spitting or fusing of atomic nuclei. Nuclear energy is radioactive and can be very dangerous because all radio-active substances undergo natural radioactive decay in which unstable isotopes spontaneously gives out fast moving particles (alpha and beta particles), high energy radiations (gamma radiation) or both at a fixed rate until a new stable isotopes is formed. These radiation whenever reaches to the air, water, soil or human bodies they changes the physical characteristic of those and known as nuclear pollution or radioactive pollution.

5.8.1 Sources of Radioactive Pollution

Radioactive pollution occurs during the phase of reactor operation, chemical reprocessing of spent fuel and waste disposal. Various sources of radioactive pollution can be grouped into

Natural sources: Cosmic rays from outer space, soil, rocks, air, water and food which contain one or more radioactive substances.

Man made sources: Nuclear plants, nuclear accidents, X-rays, diagnostic kits, test laboratories etc. where radioactive substances are used.

5.8.2 Effects of Radiations

Mining, milling and refining of uranium and thorium ore may result in considerable radiation hazard to the worker. The most significant hazard in uranium mining is through the inhalation by workers of radon gas and its decay products.

Under normal working conditions, the public and the workers in the industry are exposed to low level background radiations that cause both somatic and genetic damage.

- **Genetic damage**: Genetic damage is caused by radiations which include mutation in the DNA, thereby affecting genes and chromosomes. The damage is often seen in the off springs and may be transmitted up to several generations.
- **Somatic damage**: Includes burns, eye cataract and cancer of lungs, bone, skin and thyroid etc.

In addition to the radioactive pollution problems, they also cause thermal pollution when these substances are disposed in different water bodies.

5.8.3 Control of Nuclear Pollution

1. Sating of nuclear power plants should be carefully done after studying long-term and short-term effects.
2. Proper disposal of wastes from laboratories involving the use of radioactive isotopes should be done.
3. Precautions should be taken while drilling, a radioactive substance.

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CASE STUDIES

Bhopal Gas Tragedy

The Bhopal disaster is an example of industrial pollution accidents. Bhopal provides an example of the failure in handling a toxic material in large scale chemical processing and the consequences that have to be faced by a city in a short time. The disaster struck Bhopal on 3 December, 1984 at mid-night when pesticide manufacturing plant (Union Carbide factory) released a potent toxicant methyl isocynate gas (MIC) into the atmosphere due to the alleged functional failure of vent scrubber outlet. About 30 tons of the gas escaped from underground storage tanks resulting in the deaths of about 1,00,000 people and severe disability of an additional 1,00,000 of the city's population. The chief causes of deaths and casualties were violent coughing, eye infection (chemical conjunctivitis), suffocation, cardiac failure and pulmonary disorders. The full consequences are not yet known.

London Smog (Chemical Smog)

This type of smog is thought to be caused by sulphur dioxide. It is formed by combination of smoke, dust, fog and SO_2. Chemical smog is usually formed around some industrial and power plants. It is generally bad in early morning hours and become worse after sunrise, due to sunlight induced oxidation of SO_2 to SO_3 followed by reaction with humidity. Sulphuric acid is formed in this type of smog, which is very harmful to people suffering from bronchial diseases such as asthma or emphysema.

On Thursday, 4 December 1952, a high temperature air mass moved over Southern England and thus creates a temperature inversion and caused white fog to settle over London. As the particulate and sulphur dioxide levels rose, due to the extensive use of coal-fired heating and power production system, the fog began to blacken. The high pressure area stalled and the pollutant build-up worsened further, since there were no air currents to disperse the smog. By Friday morning, visibility was zero. According to an eye-witness such was the state that white collar became almost black within 20 minutes.

The smog so formed was intensely irritating to the human respiratory system. As a result, most of the people soon developed red eyes, hurning throats and nagging coughs. Soon, reports of smog-related deaths began to come in. The elderly and the people with chronic respiratory problems became the first casualty; followed by young and otherwise healthy persons. More than 4,000 people died before the fog disappeared/lifted on 9 December 1952.

Los Angeles Smog (Photochemical Smog)

Photochemical smog is associated with adverse meteorological conditions (inversion conditions), when the air movement is restricted in highly motorised areas. The first noticed [illegible]dence of photochemical smog was is Los Angeles, USA, in the mid-1940's and thus, it is sometimes referred as Los Angeles smog.

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Photochemical smog is oxidising smog having a high concentration of oxidants. Photochemical smog is a mixture of reactants and products that result from the interaction between volatile organic compounds (VOCs) and oxidants (such as NO_x, O_3, CO etc.). The primary pollutants in photochemical smog are nitric oxide and hydrocarbons. These primary pollutants convert rapidly to the secondary pollutants like ozone, organic nitrates (peroxyacetyl nitrate), oxidised hydrocarbons and photochemical aerosols in the presence of sunlight. It is characterised by brown and hazy fumes which reduce visibility, cause eye and lung irritation, damage crops, leads to the cracking of rubber, damage of plants, etc.

In India, Mumbai and Kolkata are ideal conditions for the formation of photochemical smog, but it may be masked by smoke and SO_2.

In a vastly oversimplified from, the production of photochemical smog can be represented by the following equation:

$$HCs + NO_x \xrightarrow{\text{Sunlight}} \text{Photochemical Smog}$$

But in actual practice, there are many complex reactions which take place in the formation of photochemical smog.

Normal NO_2 photolytic cycle:

$$NO_2 + hv \rightarrow NO + O$$

$$O + O_2 \xrightarrow{M} O_3 \quad \text{where M is a third molecule (usually } N_2/O_2)$$

$$NO + O_3 \rightarrow NO_2 + O_2$$

Production of hydroxyl radical:

$$O_3 + hv \rightarrow O^+ + O_2$$

$$O^+ + H_2O \rightarrow 2OH$$

Chain and disturbance reactions:

$$\left[\begin{array}{l} CO + OH^\circ \rightarrow CO_2 + H^\circ \\ H^\circ + O_2 \rightarrow HO_2^\circ \\ HO_2^\circ + NO \rightarrow NO_2 + OH^\circ \end{array}\right.$$

$$\left[\begin{array}{l} RCHO + OH^\circ \rightarrow RC(O)^\circ + H_2O \\ RC(O)^\circ + O_2 \rightarrow RC(O)O_2^\circ \\ RC(O)O_2^\circ + NO_2 \rightarrow RC(O)O_2NO_2 \end{array}\right.$$

$$\left[\begin{array}{l} RC(O)O_2^\circ + NO \rightarrow NO_2 + RC(O)O^\circ \\ RC(O)O^\circ + O_2 \rightarrow RO_2^\circ + CO_2 \\ RO_2^\circ + NO \rightarrow RNO_3 \end{array}\right.$$

$$\left[\begin{array}{l} RO_2^\circ + NO \rightarrow NO_2 + RO^\circ \\ RO^\circ + O_2 \rightarrow R'CHO + HO_2^\circ \\ HO_2^\circ + NO \rightarrow NO_2 + OH^\circ \end{array}\right.$$

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$$\begin{cases} RH + OH^{\circ} \rightarrow R^{\circ} + H_2O \\ R^{\circ} + O_2 \rightarrow RO_2^{\circ} \end{cases}$$

$$\begin{cases} RCHO + h\nu \rightarrow R^{\circ} + HCO^{\circ} \\ HCO^{\circ} + O_2 \rightarrow CO + HO_2^{\circ} \end{cases}$$

Terminating Reaction:

$$\begin{cases} OH^{\circ} + NO_2 \rightarrow HNO_3 \\ RO_2^{\circ} + NO \rightarrow RNO_3 \\ RC(O)O_2^{\circ} + NO_2 \rightarrow RC(O)O_2NO_2 \end{cases}$$

Photochemical smog is oxidizing smog and it should be clearly distinguished from the London smog which forms due to the combination of smoke and fog.

Mina-Mata Disease

In the early 1950s, people of Mina-mata (a small coastal town in Japan) noticed a strange behaviour of their cats. Their cats were twitching, stumbling and jerking; that they called 'dancing cats'. But the fact was that the cats were suffering from brain damage known as 'methyl mercury poisoning'.

The Chisso chemical plant used to release the residues containing mercury into Mina-mata bay. It was assumed that elemental mercury, which is insoluble in water, would sink into the bottom sediments converted the elemental mercury into soluble methyl mercury. This soluble methyl mercury was finally absorbed by the tissues of aquatic organisms, particularly fishes. These fishes, containing about 50 ppm of mercury, when consumed by people lead to an epidemic of nervous problem including numbness, tingling sensation, headaches, blurred vision, loss of muscle control and slurred speech. About 50 people died and more than 3,500 were affected. Mina-mata tragedy was probably the first water pollution episode of modern times.

Japan, Sweden and Canada are still suffering from 'Mina-mata Diseases' due to widespread use of mercury compounds as algicides and fungicides in agriculture, pulp and paper industries and chloro-alkali plants.

5.9 SOLID WASTE MANAGEMENT

All solid and semi-solid waste arising from human and animal activities, except human-excrete and sullage (liquid wastes from bathroom and kitchen etc.) are discarded as useless or unwanted are included in the term solid wastes. The term solid wastes encompasses the highly heterogeneous mass of discarded materials or throw-aways from urban community as well as the more homogeneous accumulation of waste generated by agricultural, industrial and mining activities. Solid waste (waste other than liquid or gaseous) can be classified as municipal, industrial, agricultural, medical, mining waste and sewage sludge.

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5.9.1 Sources and Classification of Solid Wastes

Solid waste may be classified based party on content and partly on moisture and heating value. A typical classification is as follows:

Municipal Solid Waste

Municipal solid waste consists of household waste, construction and demolition debris, sanitation residue, and waste from streets. This garbage is generated mainly from residential and commercial complexes. They may be categories as:

Garbage: Refers to the putrescible solid waste constituents produced during the preparation or storage of meat, fruit, vegetable etc. These waste have a moisture content of about 70% and a heating value of around 6×10^6 J/kg.

Rubbish: Refers to non-putrescible solid waste constitute, either combustible or non-combustible. Combustible wastes would include paper, wood, scrap, rubber,. leather etc. While non-combustible waste are metals, glass, ceramics etc. These waste contain a moisture content of about 25% and the heating value of the waste is around 15×10^6J/kg.

Hospital Waste

Hospital waste is generated during the diagnosis, treatment, or immunisation of human beings or animals or in research activities in these fields or in the production or testing of biologicals. It may include wastes like sharps, soiled waste, disposables, anatomical waste, cultures, discarded medicines, chemical wastes, etc. These are in the form of disposable syringes, swabs, bandages, body fluids, human excreta, etc. The moisture content is 85% and there are 5% non-combustible solids. The heating value is around 2.5×10^6 J/kg. This waste is highly infectious and can be a serious threat to human health if not managed in a scientific and discriminate manner.

Industrial Waste

They include chemicals, paints, sand, metal ore processing, fly ash, sewage treatment sludge etc. Manufacturing industries produce wastes which are solid or semi-solid. This waste can be self-igniting, explosive, toxic or radio-active. Chemical process industries generate a variety of waste, both organic and inorganic, which are mixtures with wide range of component concentration.

Agricultural Waste

These include farm animal manure and crop residue etc. Animal and vegetable waste contain valuable minerals and nutrients. Humus, from agricultural wastes, contains nitrogen, phosphorus, potash and trace elements which are vital to the fertility of the soil and optimum plant growth, but burning of wastes as fuel in the conventional manner makes poor use of the leaf content of the fuel burnt and further, leads to loss of valuable nutrients. In India, agricultural wastes contain around 2 kg/person/day.

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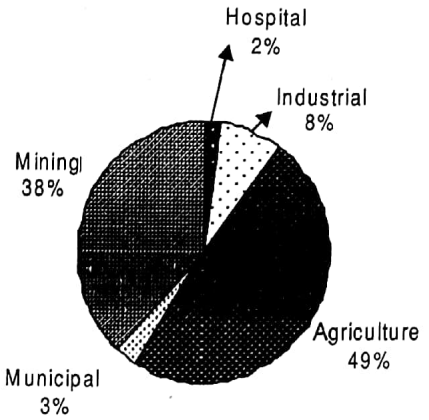

Fig. 5.8 Sources of Solid Waste

5.9.2 Causes of Solid Waste

The main causes for the rapid growth in the quantity of solid waste are:

1. **Overpopulation:** Due to increasing industrialisation and population large quantities of wastes are being generated in different forms such as: solid, liquid, sludge and gases. Each city produces tones of solid wastes daily from households, hospitals, industry offices, market centers etc. Some of these are biodegradable while others are non-biodegradable and hazardous waste. Wastes are directly thrown away on the street roads, city garbage collecting places etc., out of which most still remain there, which later pile up and chock cities drainage lines.
2. **Urbanization:** Due to pressure of urbanization most of the cities are growing fast and sometimes they develop beyond the planned limits. Generally the unplanned areas of the city contain a quarter of the total population, where the spatial information is missing because of non-availability of up to date maps. Earlier waste disposal did not pose problem due to less population. But due to rapid urbanization and lack of public awareness, proportionate increase in domestic and industrial solid waste generation was observed in large cities.
3. **Affluence:** With the affluence, there is a tendency to declare items as being in or out of fashion and the items those are out of fashion results solid waste pollution.
4. **Technology:** As the country achieves the economical goals the country invest more over technology. With the development in technology, there is a shift from natural goods to the artificial ones those are generally non-biodegradable by nature such as plastic, DDT etc. These non-biodegradable products are largely responsible for causing solid waste pollution because they persist unchanged in disposal operations such as landfills.

5.9.3 Effects of Solid Waste

1. Hazardous solid wastes are injurious to human health; some have acute effects while others pose a health hazard after prolonged period of exposure. Improper disposal of such wastes has resulted in the death of human and animals through contamination of crops and water supplies.

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2. Solid waste disposal increases the rate of breeding of disease vectors, primarily files and rats.
3. There is danger of water pollution when the leachate from a solid waste dump enters surface water or groundwater resource.
4. In addition, uncontrolled burning of open dumps can cause objectionable odour and air pollution.
5. Improper handling of solid waste causes damage to the environment. The environmental damage caused by solid waste is mostly unaesthetic in nature. Uncontrolled dumping of urban waste destroys the beauty of the country-site.

5.9.4 Management of Solid Waste

Some of the waste can be recovered and reprocess by a procedure commonly known as recycling. However, before the waste can be disposed off effectively, they must be collected efficiently. These activities, i.e., collection, disposal and/or recovery are known as solid waste management. Four R's (Refuse, Reuse, Recycle, and Reduce) to be followed for waste management:

1. **Refuse.** Instead of buying new containers from the market, use the ones that are in the house. Refuse to buy new items though you may think they are prettier than the ones you already have.
2. **Reuse.** Do not throw away the soft drink cans or the bottles; cover them with homemade paper or paint on them and use them as pencil stands or small vases. Use shopping bags made of cloth or jute, which can be used over and over again.
3. **Recycle.** Segregate your waste to make sure that it is collected and taken for recycling.
4. **Reduce.** Reduce the generation of unnecessary waste, e.g. carry your own shopping bag when you go to the market and put all your purchases directly into it.

5.9.5 Control Measures

Solid waste management is a manifold task involving many activities like–

Collecting of Solid Waste

The essential parts of the overall solid waste management programme are effective collection and transportation. The basic mode of collection is from communal storage point. The waste is delivered to fixed storage bins usually built from concrete blocks to the location from where the collection vehicle will ultimately transport it to the site of disposal. Daily collection is essential because the organic matter in the waste tends to decompose rapidly in the hot climate.

Disposal of Solid Waste

As cities are growing in size with a rise in the population, the amount of waste generated is increasing becoming unmanageable. The local corporations have adapted

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different methods for the disposal of waste – open dumps, landfills, sanitary landfills, composting and incineration plants.

Open dumps

Open dumping of solid waste is done in low lying areas and outskirts of the towns and cities. Being comparatively cheaper and required no planning, this method of disposal is used extensively in India.

Open dumps refer to uncovered areas that are used to dump solid waste of all kinds. The waste is untreated, uncovered, and not segregated. It is the breeding ground for flies, rats, and other insects that spread disease. The rainwater run-off from these dumps contaminates nearby land and water thereby spreading disease. They also become a source of objectionable odours and cause air pollution when the wastes are burned in order to reduce their volume and conserve space.

Landfills

Landfills are generally located in urban areas where a large amount of waste is generated and has to be dumped in a common place. Unlike an open dump, it is a pit that is dug in the ground. The garbage is dumped and the pit is covered thus preventing the breeding of flies and rats. At the end of each day, a layer of soil is scattered on top of it and some mechanism, usually earth-moving equipment is used to compress the garbage, which now forms a cell. Thus, every day, garbage is dumped and becomes a cell. After the landfill is full, the final layer is covered by final cover of about one metre of earth to prevent rodents from burring into the refuse and scattering and the site can thereafter be developed as a parking lot or a park.

Landfills have many problems as all types of waste are dumped in landfills and when water seeps through them it gets contaminated and in turn pollutes the surrounding area. This contamination of groundwater and soil through landfills is known as leaching.

Sanitary landfills

Sanitary land filling involves the disposal of municipal wastes on or in the upper layers of the earth's mantle especially in degraded area in the need of restoration. An alternative to landfills which will solve the problem of leaching to some extent is a sanitary landfill which is more hygienic and built in a methodical manner. These are lined with materials that are impermeable such as plastics and clay, and are also built over impermeable soil. The advantages of a sanitary landfill, as opposed to an open dump are:

1. The public health problems are minimised because flies, rats and other pests are unable to breed in the covered refuse.
2. There is no air pollution from burning.
3. Fire hazards are minimal.

Constructing sanitary landfills is very costly and they are having their own problems. Some authorities claim that often the plastic liner develops cracks as it reacts with various chemical solvents present in the waste.

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The rate of decomposition in sanitary landfills is also extremely variable. This can be due to the fact that less oxygen is available as the garbage is compressed very tightly. It has also been observed that some biodegradable materials do not decompose in a landfill. Another major problem is the development of methane gas, which occurs when little oxygen is present, i.e. during anaerobic decomposition. In some countries, the methane being produced from sanitary landfills is tapped and sold as fuel.

Incineration plants

This process of burning waste in large furnaces is known as incineration. In these plants the recyclable material is segregated and the highly combustible wastes like plastics, cardboard, paper, rubber and combustible wastes like cartons, wood scrap, floor sweepings, food wastes etc. are subjected to incineration i.e. burning at very high temperatures. At the end of the process all that is left behind is ash. During the process some of the ash floats out with the hot air, this is called fly ash. Both the fly ash and the ash that is left in the furnace after burning have high concentrations of dangerous toxins such as dioxins and heavy metals. Disposing of this ash is a problem. The ash that is buried at the landfills, leaches the area and cause severe contamination.

Burning garbage is not a clean process as it produces tones of toxic ash and pollutes air and water. A large amount of the waste that is burnt here, can be recovered and recycled. In fact, at present, incineration is kept as the last resort and is used mainly for treating the infectious waste.

The advantages of incineration include wide range ability for handling varying loads and small space requirement for ultimate disposal. However, the method requires fairly high level of maintenance and the operation of sanitary landfill.

Composting

Organic matter constitutes 35%-40% of the municipal solid waste generated in India. This waste can be recycled by the method of composting, one of the oldest forms of disposal. It is the natural process of decomposition of organic waste that yields manure or compost, which is very rich in nutrients. Composting is a biological process in which microorganisms, mainly fungi and bacteria, convert degradable organic waste into humus like substance. This finished product, which looks like soil, is high in carbon and nitrogen and is an excellent medium for growing plants. It recycles the nutrients and returns them to the soil as nutrients.

Apart from being clean, cheap and safe, composting can significantly reduce the amount of disposable garbage. The organic fertilizer can be used instead of chemical fertilizers and is better specially when used for vegetables. It increases the soil's ability to hold water and makes the soil easier to cultivate. It helped the soil retain more of the plant nutrients.

Composting: Some Benefits

1. Compost allows the soil to retain more plant nutrients over a longer period.
2. It supplies part of the 16 essential elements needed by the plants.

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3. It helps reduce the adverse effects of excessive alkalinity, acidity, or the excessive use of chemical fertiliser.
4. It makes soil easier to cultivate.
5. It helps keep the soil cool in summer and warm in winter.
6. It aids in preventing soil erosion by keeping the soil covered.
7. It helps in controlling the growth of weeds in the garden.

Pyrolsis or destructive distillation

In this disposal method, the solid wastes are heated under anerobic conditions *i.e.* burning without oxygen. The organic components of the solid wastes split up into gaseous liquid and gaseous fractions (CO, CO_2, CH_4, tar, charred carbon). Unlike the highly exothermic process of combustion, pyrolysis is a highly endothermic process and that is why it is also called destructive distillation

Land farming

The organic wastes are either applied on top of the land or injected below the soil surface with suitable equipment, where they undergo bacterial and chemical decomposition. At frequent intervals, the land farming sites can be reused without any adverse effects provided the land farming site is properly managed.

Waste Utilization

A developing country cannot afford wastage. By proper utilisation of solid waste a developing country like India can avail of many advantages. Many solid wastes generated by industries can be utilised directly. Fly ash and bottom ash from power plants can be used commercially, largely as cement substitute. New uses are developed for fly ash, e.g. to make bricks, to dewater industrial wastewater sludge, as a land cover etc. Recycling involves the collection of used and discarded materials, processing these materials and making them into new products. It reduces the amount of waste that is thrown into the community dustbins thereby making the environment cleaner and the air fresher to breathe.

5.10 ROLE OF INDIVIDUAL IN PREVENTION OF POLLUTION

Each individual should change his or her life style in such a way as to reduce environmental pollution. It can be done by the following some of the following suggestions:

- Help more in prevention than pollution control.
- Use eco-friendly products.
- Cut down the use of CFC's as they destroy the ozone layer.
- Reduce dependency on fossil fuel especially coal or oil.
- Adopt and populise renewable energy sources.
- Improve energy efficiency.
- Promote reuse and recycling wherever possible.
- Use mass transport system.

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- Use optimum amount of pesticides.
- Use rechargeable batteries.
- Use less hazardous chemical wherever application cab be afforded.
- Use low phosphate, biodegradable dish washing and laundry detergents.
- Use organic manure instead of commercial inorganic fertilizers.
- Do not dispose pesticides, paints, solvents or oil into the drain.
- Use minimum amount of water for various activities.
- Save electricity by not wasting it when not required because electricity generated without polluting the environment.
- Do not cut trees and plant more trees.
- Check population growth so that demand of material is under control.

5.11 DISASTER MANAGEMENT

The term '*Disaster*' is derived from the French word '*Desastre*' meaning a bad or an evil star. A disaster is that sudden calamity which brings misfortune and miseries to humanity. Disasters have serious impact on human life, economy and environment. They disrupt the normal pattern of life because a disaster is often severe, sudden, unexpected and widespread. They are, however, disastrous in their impacts when they affect human settlements.

Natural disasters are always severe and sudden. Some disasters are geological in nature like the earthquake, landslide, volcanic eruption etc. Some are climatic disaster like floods, droughts, cyclones etc. There are some man-induced disasters as well, like nuclear explosions, industrial accidents, wars or battles etc.

5.11.1 Earthquake

Earthquake occurs due to sudden movements of earth's crust. An earthquake is the shaking of the earth caused by pieces of the earth's crust that suddenly shift. The crust, the thin layer, is mostly cold and brittle rock compared to the hot rock deeper inside. This crust is full of large and small crakes called faults. Although these faults can be hundreds of miles long, usually you cannot see the crakes because they are buried deep underground and because the pieces of crust are compressed together very tightly. The powerful forces that compress these crustal pieces also cause them to move very slowly. When two pieces that are next to each other get pushed in different directions, they will stick together for a long time (many years), but eventually they will break apart and move. This sudden shift in the rock shakes all of the ground around it. The point on a fault at which the first movement occurs during an earthquake is called the epicenter.

Earthquake occurs because of a sudden release of stored energy. This energy has built up over long period of time as a result of tectonic force within the earth, Earthquakes are measured by the Richter scale, which measures the energy released in an earthquake by measuring the size of the seismic waves.

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Protection from earthquake:

- River banks must be strengthened by building dykes.
- Building design should be such that it has sufficient strength to withstand the vibration.
- Roofs should be placed on iron beams.
- In hilly areas, lighter material, as wood should be used for building houses.

Few major cases of earthquake in India are listed below:

Year	Location
20 Oct. 1991	Uttarkashi (Uttaranchal)
30 Sep1.993	Latur (Maharashtra): the Latur earthquake took a toll of about 10,000 lives
22 May 1997	Jabalpur (Madhya Pradesh)
29 May 1999	Chamoli (Uttar Pradesh)
26 Jan. 2001	Bhuj (Gujarat): the Bhuj earthquake killed more than 13,000 people and destroyed about 8 lakh houses
Dec. 2005	Pakistan Occupied Kashmir

5.11.2 Flood

Floods are the most common and widespread of all natural disasters except fire. Generally, the stream channels accommodate some maximum stream flow. However, due to heavy rains or sudden snow melts, the quantity of water in streams exceeds their capacity and water overflows the banks and causes inundation of surrounding land. This condition is called flood.

In some counties like India and Bangladesh rainfall does not occur throughout the year, rather 90% of it is concentrated into a few months (June-September). Heavy rainfall often causes floods in the low-lying coastal areas. Prolonged downpour can also cause the overflowing of lakes and rivers resulting into floods.

Deforestation, overgrazing, mining, rapid industrialisation, global warming etc. have also contributed largely to a sharp rise in the incidence of floods, which otherwise is a natural disaster.

River floods, caused primarily due to the peculiarities of rainfall in the country, are the most frequent and often the most devastating disaster in India. The problem of floods are compounded by sediment deposition, drainage congestion and the synchronization of river floods with sea tides in the coastal plains. The rivers originating in the Himalayas carry a large amount of sediment, causing erosion of the banks in the upper reaches and over-topping in the lower segments.

The most flood-prone areas are the Brahmaputra, Ganga and Meghana basins in the Indo-Gengetic-Brahmaputra plains in north and northeast India, which carry 60% of the nation's river flow.

People of India and Bangladesh are accustomed to moderate flooding during monsoon period and they utilise the flood water for growing paddy in their fields.

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However, severe floods like that in 1988 and 1991 resulting from excessive Himalayan runoff and storms, had very disastrous results causing massive loss of human life and damages to properties. In 1970 flood, nearly one million people were drowned while more than one lakh people died in 1991 floods.

The mitigation measures for flood include both structural and non-structural measures. The structural measures include:

- Prevention of over bank spilling by the construction of embankment and flood walls.
- Improvement of flow conditions in the channel and anti-erosion measures.
- Improve drainage.

The non-structural measures include:

- Flood plan management.
- Maintaining wetland.
- Flood forecasting and warning services.
- Disaster relief, flood fighting and public health measures.
- Flood insurance.

5.11.3 Cyclone

A cyclone is an area of low pressure in the centre and high pressure outside. It is a powerful swirling storm that measures from 300 to 500 km in diameter. The wind in the centre of a cyclone blows at a speed of 120 km/hr. The cyclones, thus, can be defined as travelling low pressure areas, roughly circular or oval in shapes, which originate as a wave along the front separating two airmasses of different temperature, density and direction. They produce clouds and rain because a warm moist air is made to rise over a mass of cold air.

The intense tropical stroms are known in different parts of the world by different manes. In the Pacific ocean, they are called '*typhoons*', in the Indian ocean they are called '*cyclones*' and over North Atlantic they are called '*hurricanes*'. Among various natural calamities, tropical cyclones are known to claim a higher shear of deaths and destruction world over. Records show that about 80 tropical cyclones from over the globe every year. India has a vast coast line which is frequently affected by tropical cyclones causing heavy loss of human lives and property. Cyclones occur usually between April and May (called pre-monsoon cyclonic storms) and between October and December (called post-monsoon cyclonic storms).

A severe cyclonic storm with wind speed of about 260 kmph hit Orissa coast at Paradip on 29th October 1999 causing extensive damage to human life, property, livestock and public utilities.

Mitigation Measures

- Installation of early warning system.
- Developing communication infrastructure.

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- Developing shelter belts.
- Developing community cyclone shelters.
- Construction of permanent houses.
- Training and education about cyclone.
- Land use control settlement planning.

5.11.4 Landslides

Landslides refer to rapid down slope movement of soil or rock. Landslide occurs as a result of alteration of the natural slope by sharp steeping or cutting into slope or removing material at the base of the slope. In a landslide, a section of ground slumps forward, away from down the hill and at the toe, some material may even be scooped out from below the original ground level.

Actually the process of landslides starts with a simple process of erosion involving the removal of crystal material of earth surface due to weathering, abrasion and transportation. The process of top-soil erosion begins with the splatter of the first rain-drop. Rain water, which does not seep into ground, forms tiny rivulets carrying material downhill to be washed away by rivers. There is a natural angle of repose for rock and soil material. As long as the slope of a hillside is less than that angle, the slope remains fairly stable. When the ground is saturated with water, the angle of repose is usually less than if the ground was dry. If any change occurs in this natural condition of slope, landslide is resulted.

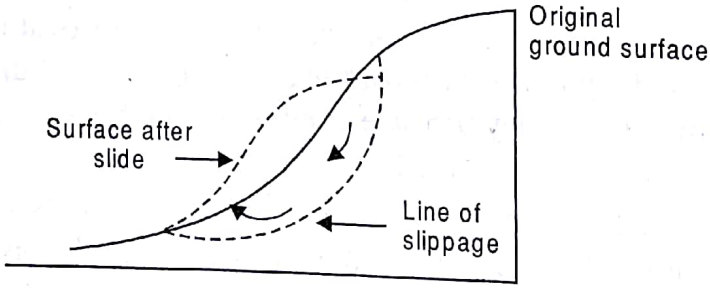

Fig. 5.9 Landslide due to slope failure

Landslides often block streams or rivers due to which water overflow from the banks and causes floods. Human activities such as road construction, deforestation, agricultural cultivation and building construction on steep and unstable slopes increase both the frequency and the damage done by landslide.

The hazard caused by landslides can be achieved by preventing the exposure of population and facilities to landslide and by physically controlling the landslide. Developmental programme that envelop modification of the topography and exploration of natural resources and change in the balance load on the ground should not be permitted. Some critical measures that could be undertaken to prevent further land slide are drainage measure, erosion control measure such bamboo check dams, terracing, jute and coir netting and rock fall control measures such as grass plantation, vegetated dry masonry walls, retaining walls and most importantly preventing deforestation and improving afforestation.

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5.11.5 Volcanic Eruption

Volcano is an opening in the earth's crust through which molten lava, ash, and gases are ejected. A mountain formed by the materials ejected from a volcano. Volcano is vents or fissures in the earth's crust through which gases, molten rock, or lava and solid fragments are discharged. Volcanoes are described as active, dormant, or extinct. The soil resulting from decomposition of volcanic materials is extremely fertile, and the ash itself is a good polishing and cleansing agent. It is known that an eruption usually follows movement of magma (a mixture of finely divided solids with enough liquid to produce a pasty mass) upwards into the solid layer (the earth's crust) beneath a volcano and occupying a magma chamber (a magma chamber is the chamber beneath a volcano where the magma is held before an eruption). Eventually, magma in the chamber is forced upwards and flows out across the planet surface as lava, or the rising magma can heat water in the surrounding landform and cause explosive discharges of steam; either this or escaping gases from the magma can produce forceful ejections of rocks, cinders, volcanic glass, and/or volcanic ash also known as tephra. While always displaying powerful forces, eruptions can vary from effusive to extremely explosive.

Increases in temperature and pressure with depth cause formation of magma (melt). This melt is less dense than the surrounding mantle and will consequently raise though the mantle to the overlying crust. As the magma (melt) rises through the crust it may melt and assimilate some of the surrounding crust, it may cool and begin to grow crystals, and it may exsolve gas. If the magma reaches the surface, it will generate a volcanic eruption.

CASE STUDIES

Case Studies Disaster Management

Southern Leyte Landside, 2006

On February 17, 2006 a series of mudslide caused widespread damage and loss of life in the Philippine province of Southern Leyte. The deadly landslides followed a ten-day period of heavy rains and a minor earthquake of magnitude 2.6 on the Richter scale. Fifty people are confirmed dead, but with 958 people still missing the death toll is expected to rise dramatically.

The municipality of Saint Bernard was one of the worst hit areas, where twenty-three are confirmed to be dead with up to 200 estimated as dead and another 1,500 missing. Barangay Guinsaugon, a mountain village on the said municipality with 2,500 people, was almost completely destroyed.

Thredbo, NSW, Landslide, 1997

At about 11.30 pm on 30 July 1997 Australia's worst landslide occurred when a large section of steep mountainside below the Alpine Way road collapsed immediately above part of Thredbo Ski Village in the NSW Alps. About 1,000 tonnes of earth, rock and trees slid rapidly down the steep slope: firstly shearing the *Carinya Lodge* off its foundations; and then, causing it to collide with the *Bimbadeen Lodge* at high speed. Both

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multi-level buildings were completely crushed and their debris and parked cars scattered over and under the lower 250 m of the 400 m landslide. Rescue efforts were hampered by several further minor 'slides' and the very unstable mass of earth, rock, shattered lodges and trees and vehicles. All major emergency services took part in a tedious and cautious search and rescue operation, firstly securing broken water, gas and oil lines and precariously balanced boulders and concrete slabs. Thermal imaging cameras and seismic listening devices were used to aid in finding survivors. Over seven days of exhaustive searching, rescuers recovered the 18 bodies of those who died in this tragic disaster which also caused damage worth many millions of dollars.

Latur Earthquake, India, 1993

On September 29, 1993 (local time Sep. 30, 4.29 h) an earthquake of magnitude 6.3 struck the Latur region of Maharashtra, India and claimed about 10,000 lives and injured 30,000 people. This is the highest death toll due any stable continental region earthquake, so far. The earthquake had severely damaged the villages Killari, Sastur, Holli, Yekundi, Kawtha, Rajegaon, Mudgar, Makni and others.

There is some evidence for the occurrence of earthquakes in this region in historical times. The closest seismological observatory in Hyderabad, about 200 km east of the epicentre, is in operation since December 11, 1967.

Gujarat Earthquake, India, 2001

The epicentre of the Gujarat earthquake was a small town called Bhuj. At 08:46 local time, on Friday 26th January 2001 it was struck by an earthquake that measured 7.9 on the Richter scale. It turned out to be one of the two most deadly earthquakes in the recorded history of India, with almost 20,000 people confirmed as dead, and another 166,000 injured. Add to that a further 600,000 left homeless, almost 350,000 homes destroyed and another 844,000 damaged and it becomes obvious that this was a major humanitarian disaster. The Indian government has calculated that in one way or another, the 'quake had an effect on 15.9 million people - nearly half the population of India!

The cost of the damage varies depending upon who's figures you use, but it was between 1.3 billion and 5 billion US dollars. In built up areas modern buildings were shaken but mostly survived. Others, however, including several multistory concrete buildings collapsed.

Before the quake this was a rather dry area often affected by drought. After the quake there were many reports of the water table rising, sometimes to surface level. In a number of places new springs appeared, some with fresh water and others, more surprisingly, with salt water. Some desert rivers, that had been dry for over a century, began to flow again, and there was evidence of liquefaction in many places.

Kashmir Earthquake, 2005

Taking the world by shock, the 7.6 magnitude earthquake that rocked Northern Pakistan during the Muslim month of Ramadan in 2005 was utterly devastating. The seismic activity was traced to the fault line between the Eurasian and Indian plates—the same two plates that crashed together to form the majestic Himalayan Mountains. The constant collisions, friction and tension generated through this fault line make the region a seismic hotspot, and this specific earthquake occurred directly on the course of the agitated fault.

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The Pakistani government officially recorded a death toll of 87,250. However, most independent assessments lend that the death toll was in fact in excess of 100,000. Additionally, nearly 3.3 million were left homeless in Pakistan during one of the coldest winter snowfalls in recent years in the region. Furthermore, reports place that the earthquake injured 106,000. In economic terms, the damages incurred were 30,000 crore rupees which is well over 5 billion US Dollars.

Flood, Sri Lanka, 2003

The two days of torrential rains in May 2003 accompanied by heavy winds and landslides caused the worst floods Sir Lanka has known since 1947. Nearly 750,000 people were affected and 35,750 houses damage in six districts: Ratanpura, Hambantota, Matara, Galle, Kalutara and Nuwara Eliya. According to official estimates of the government, approximately 235 people died and 17 people went missing. Almost 10,000 people lived in capms setup in temples, schools in highly unhygienic conditions.

Floods, Bangladesh, 1998

Bangladesh, being located at the confluence of several of South Asia's major rivers, suffers from floods almost every year. Major portions of the country are part of the Ganga Delta, the largest flood plain in the world. The floods have caused havoc in Bangladesh throughout history, especially during the recent years: 1987, 1988, and 1998. Floods bring silt and make the soil cheap.

In 1998, over 57 per cent of the land area was flooded. In Assam in the north-east more than 1 million people lost their homes as a result of the floods. In the Nalbari district, 240 villages were submerged. Over 1000 people were killed and millions were made homeless. There were severe shortages of drinking water. Diseases such as bronchitis and diarrhoea spread. As the waters drained away, brown fields of rotting crops, villages buried in sand and silt, and wrecked roads and bridges were left behind. The floods cost the country almost $1 billion.

Droughts, Australia, 2006

In the past five to ten years major drought has struck large parts of Australia and for the first time it has begun to affect the urban population. As of October 2006 the drought has affected more than three-quarters of the country. Because of the long-term effects of the drought now showing, many state governments are now attempting to "drought-proof" their states not just for now, but for future generations.

On Thursday 12th October 2006 Melbourne recorded its hottest October day in 92 years reaching 36.6 degrees celsius - a hot summer's day temperature in the middle of spring. On this particular day over 250 wildfires burnt throughout the state of Victoria whose bushland and forest are now extremely dry from lack of rain.

Drought, India

A drought-prone locality like Kalahandi in Orissa is facing the calamitous effect of drought for many consecutive years. The sequences of drought and the diversified causes of it in the region under study are pin-pointed with the help of concrete data collected both from the field as well as from records. The geo-physical situation of Kalahandi is brought under discussion to analyse the causes and effects of drought condition. Various measures that have been taken so far by the government to resist the unfortunate situation are critically discussed, and together with these the nature and patterns of the peoples own

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efforts in adopting various strategies for fighting against the drought creating factors are presented with their problems and prospects.

Volcanic Eruption, Mt St Helens, Washington, USA, 1980

During 1980 scientists had warned that a large bulge which was developing on the snow-covered, upper-northern slopes of Mt St Helens might trigger a great avalanche or eruption. They were correct. The disaster began early on 18 May with an earthquake (magnitude 5) which loosened the whole northern slope of the mountain.

Then, in an enormous blast, hot gases, earth and rocks rocketed out of the volcano's side, flattening forests over 25km away! At the same time, furious blasts sent lava, steam, ash and rock skyward. The initial blasts ejected about 400 million tonnes of debris.

62 people died in thick ash and choking smoke and many more were injured. Damage caused by the eruption and subsequent ash-fall has never been fully calculated. Rivers were flooded and silted for up to 24 kilometres, 400 square kilometres of forests were flattened and disappeared, and roads and bridges were demolished. Total economic losses were estimated at US $1.2 billion (in 1980 values).

Volcanic Eruption, Mt Pinatubo, Philippines, 1991

On 9 July 1991, the 1,463 metre, dormant volcano near Subic Bay, came back to life after six centuries. It began a series of eruptions which were to last for months. By mid-July the eruption reached an initial, mighty climax as it belched billions of cubic metres of red-hot magma, gases and ash (tephra) from a three kilometre-long fissure (crater) near the mountain's summit. Such was the explosive force of the main eruption, that it ejected enormous clouds of ash and gas vertically to an altitude of about 40 km!

Ash fallout from the volcano settled deep on the ground over huge areas, up to hundreds of kilometres away. By mid-afternoon on 17 July, the sky was as black as night as far south as Manila (85 km away). A relentless 'rain' of golfball-size pumice pebbles and ash poured down, while thunder and lightning from a tropical storm alternated with brilliant orange flashes from the volcano. There were also numerous earthquakes, all resulting from Pinatubo's continual violent eruptions. Fortunately, because the bulk of its eruptive energy was directed vertically upwards (unlike Mt St Helens), it did not produce large pyroclastic and molten lava flows that could have devastated towns on the mountain's flanks.

A week later, heavy rains from Typhoon Brenden sent thousands of tonnes of ash, silt and volcanic debris surging down the mountain. Enormous mud flows and slides (taller than houses) wrecked many foothill villages, killed many people and forced thousands to flee from their homes.

These secondary events caused the greatest loss of life and human suffering. Over the period of eruptions, about 700 died. One million others were forced from their homes (42,000 were destroyed) and 40,000 ha of cropland were buried under ash.

Mt Pinatubo's massive eruption was the largest on record in the Philippines, and in the world for a century, producing the largest cloud of climate-modifying gases since mighty Krakatoa erupted in Indonesia in 1883. Scientists estimated that Pinatubo's eruption added more aerosols (light gases and particles) than all human-caused 'greenhouse gases' since the industrial revolution. A reduction of up to 1°C in the Earth's average temperature was recorded by NASA satellites within a year of the main eruption. This cooling effect persisted for about two years, temporarily more than offsetting any global warming effect.

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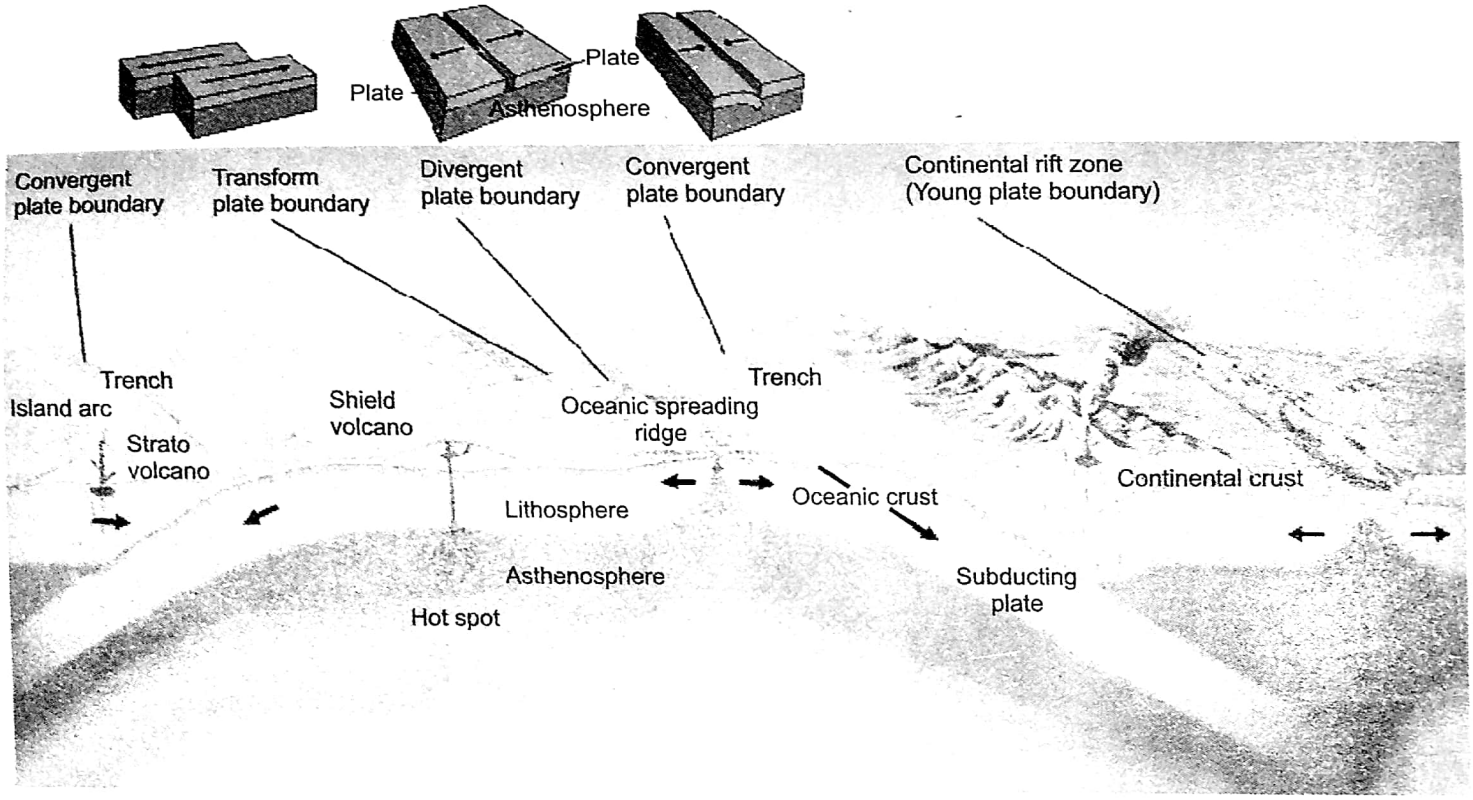

Fig. 5.10

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SUMMARY

Pollution is the release of chemical, physical, biological or radioactive contaminants to the environment. Pollution is thus direct or indirect change in any environmental components that is causing harmful effect adversely the industrial progress, culture or natural assets or general environment.

Air pollution may be defines as the presence of any contaminant in the atmosphere that tends to be injurious to human health, animal or plants or properties or would unreasonable interfere with enjoyment of life and property. Primary pollutants are those which are emitted directly into the atmosphere and Secondary pollutants are pollutants formed by the photochemical reaction of primary pollutants.

The air pollution may be due to natural disasters like dust storms, earthquakes and volcanic eruptions or man-made causes like toxic emissions from factories, power plants, vehicular traffic, etc. Depending on the pollutant, the concentration and the duration of exposure, they may cause irritation and effects mucous membranes and respiratory organs. When the temperature increases with altitude, called an inversion. This may be of three type subsidence inversion, radiation inversion and advection inversion.

Water pollution is defined as presence of any foreign substance (organic, inorganic, biological or radiological) in water which tends to degrade the quality and impair the usefulness of water. The presence of water pollutants alters the amount of dissolved oxygen and biochemical oxygen demand. Dissolved oxygen (DO) is the amount of oxygen present in the aquatic system that is available for aquatic life.

The biochemical oxygen demand (BOD) is a measure of the oxygen required by aerobic micro-organisms to bio-chemically oxidize the organic matter present in the waste. Another quick measure of organic matter present in waste is chemical oxygen demand (COD) and in this case chemical oxidants are used instant of aerobic micro-organisms for the oxidation of organic matter.

Sewage and Industrial waste are the major sources of water pollution. The water pollution can be controlled by treating polluted water by physical, chemical or biological means and removing the contaminants up to acceptable quality standards, so that water can be reused or discharged into water bodies.

Soil pollution is the introduction of substances, biological organisms or energy into the soil, resulting in a change of the soil quality, which is likely to affect the normal use of the soil or endangering public health and the living organism.

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

Thermal pollution can be defined as presence of waste heat in the water which causes undesirable changes in the natural environment. The physical or chemical change in the air, water or land due to radiation from the radioactive substances is known as radioactive pollution.

All solid and semi-solid waste arising from human and animal activities, except human-excrete and sullage (liquid wastes from bathroom and kitchen etc.) are discarded as useless or unwanted, is called solid wastes. The disposal of solid waste by least pollution the environment is known as solid waste management. Solid waste can be disposed by any of the following method depending upon the nature of waste as open dumps, landfills, sanitary landfills, incineration plants and composting.

A disaster is that sudden calamity which brings misfortune and miseries to humanity. Natural disasters are always severe and sudden. Some disasters are geological in nature like the earthquake, landslide, volcanic eruption etc. Some are climatic disaster like floods, droughts; cyclones etc. There are some man-induced disasters as well, like nuclear explosions, industrial accidents, wars or battles etc.

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DESCRIPTIVE TYPE QUESTIONS

1. What is air pollution? What are its effects on human health? Discuss the measures used for controlling air pollution. **[10 Marks](UPTU 2005)**
2. What do you understand by the term pollution and pollutants? What are the different types of pollution and how you will define them?
3. What is inversion? Define all its types and explain the causes and effects of inversion in atmosphere.
4. What is photochemical smog? How does if different from London smog? What are its effects?
5. What do you mean by Water Pollution? Discuss its major sources of water treatment with layout of a water treatment plant. **[10 Marks](UPTU 2006)**
6. What is thermal pollution? Discuss its causes and effects. State the approaches to control it?
7. Define 'Marina Pollution' and 'Thermal Pollution' and discuss the various sources contributing it. How can we prevent pollution of our oceans? **[10 Marks](UPTU 2006)**
8. Define radiation. What are the main causes, effects and control of radioactive pollution?
9. Describe the methods to control radioactive hazards. How can the nuclear waste be disposed-off effectively?
10. Define water pollution? Discuss its major sources and effects.
11. What is BOD? How is domestic discharge responsible for increasing the BOD level into the stream?
12. How inaustrial, domestic, agricultural and other wastes affect the fertility of the soil? Discuss the measures to check it.
13. What is solid waste? Explain the sources and effects of solid waste.
14. Classify the composting techniques based on oxygen use. What are the advantages of 'Vermicomposting' over conventional compositing? What are the advantages of solid waste incineration? **[10 Marks](UPTU 2006)**
15. What are 'Solid Wastes'? Discuss their types, effects and name the various methods used to dispose solid wastes. Explain any one of ten with merits and demerits. **[10 Marks](UPTU 2006)**
16. Explain the various methods commonly employed for disposal of solid waste, with their advantages and disadvantages. **[10 Marks](UPTU 2005)**
17. Write a note on solid waste management practices.
18. What do you understand by natural disaster? What measures you would take to prevent loss of lives from floods and earthquakes? Explain. **[10 marks](UPTU 2005)**
19. Give an account of environmental disasters and their management.
20. List the main features of the draft National Policy on Disaster Management in India. What are the environmental effects of oil spills and oil leaks? **[10 Marks](UPTU 2005)**
21. What are the causes of land slide? Discuss its consequences and suggest the methodology to fight back such hazards. **[10 marks](UPTU 2006)**
22. Why do earthquake occur? Suggest the management plan for mitigate the effects of earthquake. Explain the case of any earthquake that occurred in India.
23. How can you, as an individual, prevent environmental pollution? Why such an effort at individual level is important?

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SHORT QUESTIONS WITH ANSWERS

Q. 1. Name different types of pollutions. Define them.

Ans. **Air pollution** may be defines as the presence of one or more contaminants in the atmosphere in such a quantity and of such duration as is or tends to be injurious to human health of welfare, animal or plants or properties or would unreasonable interfere with enjoyment of life and property.

Water pollution is defined as presence of any foreign substance (organic, inorganic, biological or radiological) in water which tends to degrade the quality so as to constitute a hazard, or impair the usefulness of water.

Soil pollution is the introduction of substances, biological organisms or energy into the soil, resulting in a change of the soil quality, which is likely to affect the normal use of the soil or endangering public health and the living organism.

Marine pollution can be defined as the direct or indirect introduction of substances or energy into the marine environment (including estuarine), causing in harm to living resources, hazards to human health, hindrance to marine activities including fishing and impairment of the quality of sea water.

Thermal pollution can be define as presence of waste heat in the water which causes undesirable changes in the natural environment.

Q. 2. What do you understand by secondary pollutants? Give the reaction for their formation.

Ans. **Secondary pollutants** are pollutants formed by the photochemical reaction of primary pollutants. For example, "Photochemical smog", is a combination of hydrocarbons and oxides of nitrogen.

$$HCs + NO_x \xrightarrow{\text{Sunlight}} \text{Photochemical Smog}$$

Q. 3. What do you understand by the term 'epicenter'?

Ans. The **epicenter** is the point on the Earth's surface that is directly above the point where an earthquake or other underground explosion originates. The epicenter is directly above the hypocenter, the actual location of the energy release inside the earth. It is the point on a fault at which the first movement occurs during an earthquake.

Q. 4. Explain the following terms:

(i) Eutrophication (ii) Sanilization (iii) Biomagnification
(iv) PAN (v) CFC's (vi) MIC

Ans. Explain the following:

(i) As due to run off with water the nutrients reaches in the water body and that becomes rich nutrient and the rate of growth of aquatic plants increases very rapidly and the penetration of sun light to the bottom of the water body in not possible and amount of dissolved oxygen decreases that effects aquatic life, this process is known as **eutrophication.**

(ii) **Salinization** refers to a build up of salts in soil, eventually to toxic levels for plants. (3,000 - 6,000 ppm salt results in trouble for most cultivated plants.) Salt in soils, decreases the osmotic potential of the soil so that plants can't take up water from it. When soils are salty, the soil has greater concentrations of solute than does the root, so plants can't get water from soil.

(iii) **Biomagnification** is the increase in concentration of an element or compound, such as pesticides (DDT) that occurs in a food chain as a consequence of food chain energetics; or lack of or very slow, excretion or degradation of the substance.

(iv) **Peroxyacetyl nitrate (PAN)** is a **secondary pollutants** and primarily responsible for damaging to plant life and lead to the formation of photochemical smog which results eye irritation I human being.

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(v) **Chloro-fluoro-carbons** (CFCs) are ozone depleting substances such as halons (bromo-fluoro-carbons) and methyl bromide. In certain circumstances the chlorine or bromine from these substances can react with ozone to turn it back into oxygen.

(vi) **Methyl isocynate** (MIC) is a potent toxicant and was released in to the atmosphere in Bhopal on December 3, 1984 at mid-night from a pesticide manufacturing plant (Union Carbide factory) due to the alleged functional failure of vent scrubber outlet resulting in the deaths of about 1,00,000 people and severe disability of an additional 1,00,000 of the city's population.

Q. 5. Write short notes on

(i) Causes, effects and control of flood

(ii) Solid waste management practices

(iii) Sources, effects and control measures of noise pollution

Ans. Short Notes

(i) Due to heavy rains or sudden snow melts, the quantity of water in streams exceeds their capacity and water overflows the banks and causes inundation of surrounding land which results flood. It can be control by constructing embankment and flood walls, improving flow conditions in the channel and improving drainage.

(ii) **Solid Waste Management Practice** is supervised handling of waste materials from their source through recovery processes to disposal. The solid waste is non-liquid, non-soluble materials ranging from municipal garbage to industrial wastes that contain complex and sometimes hazardous substances. Solid wastes also include sewage sludge, agricultural refuse, demolition wastes, and mining residues.

(iii) Noise pollution may come from loudspeakers, factories, aeroplanes, moving trains, construction activity or even a radio. Continued exposure of noise results high levels fatigue, temporary or permanent shift of the hearing threshold of a person (hearing loss or even total loss of hearing), changes in blood circulation, changes in breathing, etc. Noise pollution could be controlled by either reducing the noise at the source or by preventing its transmission or by protecting the receiver.

Q. 6. What are the effects of ultraviolet radiations on human being?

Ans. Ultraviolet (UV) radiation emitted from the Sun. Divided into three categories, based on its wavelength; these are referred to as UV-A, UV-B, and UV-C. This UV radiation can be harmful to the skin and is the main cause of sunburn; excessive exposure can also cause genetic damage, resulting in problems such as skin cancer.

Q. 7. Mention the causes of

(i) Smog (ii) Acid rain

Ans. Causes of

(i) Some of the main sources of **Smog** are: gasoline and diesel powered vehicles, factories and utilities, oil-based paints, solvents and cleaners, pesticides, road paving (asphalt) and construction and coal-fired generating stations

(ii) Two elements, sulphur and nitrogen, are primarily responsible for the harmful effects of **acid rain**. The sulphur combines with oxygen to form sulphur dioxide. Because sulphur dioxide does not react with most chemicals found in the atmosphere, it can travel long distances. Eventually, if it comes in contact with ozone or hydrogen peroxide, it can be converted to sulphur trioxide. Sulfur trioxide can dissolve in water, forming a dilute solution of sulfuric acid. NOx is the sum of nitrogen oxide and nitrogen dioxide in a given parcel of air. These can dissolve in water, forming weak solutions of nitric and nitrous acids.

Q. 8. Name the major air pollutants and their sources.

Ans. See the Table 5.1

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Q. 9. Write short notes on

(i) Disaster management (ii) Air pollution control devices

(iii) Sources and effects of radioactive pollution.

Ans. A disaster is that sudden calamity which brings misfortune and miseries to humanity. Disasters have serious impact on human life, economy and environment. They disrupt the normal pattern of life because a disaster is often severe, sudden, unexpected and widespread. They are, however, disastrous in their impacts when they affect human settlements, so different practices those are made to overcome the result of disaster are known as disaster management.

Q. 10. Write short notes

(a) Minamata disease (b) Cyclones

(c) Bhopal gas tragedy

(d) Point, area and line source of air pollutants

(e) Land slide (f) Threshold limit of hearing

(g) Solid waste management

Ans. The minimum sound pressure level that a particular can hear is known as **threshold limit of hearing.**

Q. 11. Differentiate the following:

(a) Natural and man-made sources of pollution (with example)

(b) London smog and Los Angeles smog

(c) Wet cooling tower and dry cooling tower

(d) Fog and smog (e) Noise and sound

(f) Primary and secondary air pollutants

(g) BOD and COD (h) Pyrolysis and composting

Ans. (a) Natural sources of pollution are source those emit pollutant naturally like volcanic eruption, forest fires, bio-pollutants etc. while man made sources are those where pollutants comes in the atmosphere by human activities like burning of fossil fuels, automobiles, plants and industries.

(b) This type of smog is thought to be caused by sulphur dioxide. It is formed by combination of smoke, dust, fog and SO_2. Chemical smog is usually formed around some industrial and power plants whereas Los Angeles smog (photochemical smog) is associated with adverse meteorological conditions (inversion conditions) when air movement is restricted in summers in highly motorized areas.

(c) In wet cooling tower coolant and cooling substance both come is direst contact whereas in dry cooling tower they are in indirect contact.

(d) Fog is special type of thin colud consisting of microscopically small water droplets which are kept in suspension in the air near the ground surface while smog (smoke + fog) is two types—one is found in plance having coal as the principal fuel. The other one is photochemical smog.

(e) Sound is mechanical energy from vibrating source. Noise can be defined as an unpleasant and unwanted sound.

(f) **Primary pollutants** are those which are emitted directly into the atmosphere, like sulphur dioxide, nitric oxides and carbon monoxide while **Secondary pollutants** are pollutants formed by the photochemical reaction of primary pollutants.

(g) The **biochemical oxygen demand (BOD)** is a measure of the oxygen required by aerobic micro-organisms to bio-chemically oxidize the organic matter present in the wast and is expressed in mg/l. Another quick measure of organic matter present in waste is **chemical oxygen demand (COD)** and in this case chemical oxidants (potassium dichromate in acidic conditions) are used instant of aerobic micro-organisms for the oxidation of organic matter.

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(h) In **Pyrolsis,** the solid wastes are heated under anerobic conditions *i.e.* burning without oxygen. The organic components of the solid wastes split up into gaseous liquid and gaseous fractions (CO, CO_2, CH_4, tar, charred carbon etc.) whereas **composting** is one of the oldest forms of disposal. It is the natural process of decomposition of organic waste that yield manure or compost, which is very rich in nutrients. Composting is a biological process in which micro-organisms. mainly fungi and bacteria, convert degradable organic waste into humus like substance.

MULTIPLE CHOICE QUESTIONS

1. Which of the following is an air pollutant?
(a) Nitrogen (b) Carbon dioxide
(c) Carbon mono-oxide (d) Oxygen

2. Acid rain is caused by increase in the atmospheric concentration of?
(a) Ozone and dust (b) SO_2 and NO_2
(c) SO_3 and CO (d) CO_2 and CO

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

4. Which of the following on inhalation dissolved in the blood hemoglobin more rapidly than oxygen?
(a) Sulphur dioxide (b) Carbon monoxide
(c) Ozone (d) Nitrous oxide

5. Smog is
(a) A natural phenomenon (b) A combination of smoke and fog
(c) Is colourless (d) All of the above

6. Which of the following are likely to be present in photochemical smog?
(a) Sulphur dioxide (b) Photochemical oxidants
(c) Chlorofluorocarbon (d) Smog

7. Taj Mahal at Agra may be damaged by?
(a) Sulphur dioxide (b) Chlorine
(c) Hydrogen (d) Oxygen

8. Ozone layer of upper atmosphere is being destroyed by?
(a) Ozone (b) PAN
(c) Aldehydes (d) All of the above

9. Increasing skin cancer and high mutation rate are the result of?
(a) Ozone depletion (b) Acid rain
(c) CO_2 pollution (d) CO pollution

10. During Inversion
(a) Temperature increases with altitude
(b) Temperature decreases with altitude
(c) Temperature remains constant (d) None of the above

11. Gas leaked in Bhopal tragedy
(a) Methyl isocyanate (b) Potassium isothiocynate
(c) Ethyl isocyanate (d) Sodium isothiocyanate

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

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13. Which of the following air pollution control devices is suitable for the removing the finest dust from the air?
    (a) Cyclone separator (b) Electrostatic precipitator
    (c) Fabric filter (d) Wet scrubber
14. Air pollution from automobiles can be controlled by fitting?
    (a) Cyclone separator (b) Electrostatic precipitator
    (c) Catalytic converter (d) Wet scrubber
15. BOD is
    (a) A measure of the organic matter present in water
    (b) Usually less than COD (c) Biochemical oxygen demand
    (d) All of the above
16. Biochemical Oxygen Demand measures
    (a) Industrial pollution (b) Air pollution
    (c) Pollution capacity of effects
    (d) Dissolved O_2 needed by microbes to decompose organic waste.
17. Excess fluoride in drinking water is likely to cause
    (a) Blue baby syndrome (b) Fluorosis
    (c) Change in taste and odour (d) Intestinal irritation
18. Fluoride pollution mainly affects
    (a) Kidney (b) Brain
    (c) Heart (d) Teeth
19. Which of the following is a non-point source of water pollution?
    (a) Factories (b) Sewage treatment plants
    (c) Urban and suburban lands (d) All of the above
20. Septic tank is
    (a) An aerobic attached growth treatment system
    (b) An aerobic suspended growth biological treatment system
    (c) An anaerobic attached growth biological treatment system
    (d) An anaerobic suspended growth treatment system
21. Which of the following is not a marine pollutant?
    (a) Oil (b) Plastics
    (c) Dissolved oxygen (d) All of the above
22. Noise is
    (a) Loud sound (b) Sound of high frequency
    (c) Unwanted sound (d) Constant sound
23. Which of the following is a major source of thermal pollution in water bodies?
    (a) Sewage treatment plant (b) Solid waste disposal sites
    (c) Thermal power plant (d) All of the above
24. Which of the following is a likely characteristic of hazardous waste?
    (a) Ignitability (b) Corrosivity
    (c) Reactivity (d) Any of the above
25. High level radioactive waste can be managed in which of the following ways?
    (a) Open dumping (b) Composting
    (c) Incineration (d) Dumping in sealed containers
26. Biomedical waste may be disposed off by?
    (a) Incineration (b) Autoclaving
    (c) Land filling (d) Both (b) and (c)
27. Disease caused by eating fish inhabiting mercury contaminated water is
    (a) Bright's disease (b) Hiroshima episode
    (c) Mina-mata disease (d) Osteosclerosis

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