are abstractions. No two ecosystems are exactly alike. **An ecosystem concept is that the living organisms of a community not only interact among themselves but also have functional relationship with their nonliving environment. This structural and functional system of communities and their environment is called an ecosystem.**

FUNCTIONING AND TYPES OF ECOSYSTEM

Functioning of the ecosystem is self-regulating and self-sustaining. This depend upon flow of energy, cycling of materials and perturbations both intrinsic and extrinsic. It is recognised as a dynamic concept with structural hetergeneity based on at least four functional phases. A rapid release phase consisting of tightly bound resources is replaced by a reorganisation phase followed by a exploitative phase, which gradually transformed into conservation phase or climax phase. The control of ecosystem function by nutrient flux and the condition of the physical environment is called Bottom-up-control but function via tropic interactions is called Top-down control.

Depending upon the species, diversity and the manner in which they are organised, Ecosystems are of following types —

1. Permanent and Natural ecosystem. These operate under natural conditions without any interference (even by human beings). These can be further classified in to—

(*i*) Terrestrial ecosystem

(*ii*) Aquatic ecosystem

Terrestrial ecosystems operate on land hence Forest, Desert and grassland and Agro-ecosystems included in this type. While Aquatic ecosystem operates in water. It can be devided in two

(*a*) Fresh water ecosystem

(*b*) Marine ecosystem

Freshwater ecosystems are usually named after the size and nature of the fresh water body such as pond, lake & river.

Marine ecosystem is largest ecosystem on earth, which consists of several sub-divisions each having its physico-chemical and Biological characteristics. For example, in the deepest ocean producers are absent but in many other organisms survive which dependent for food on the dead organic matter coming from the upper layers of the ocean.

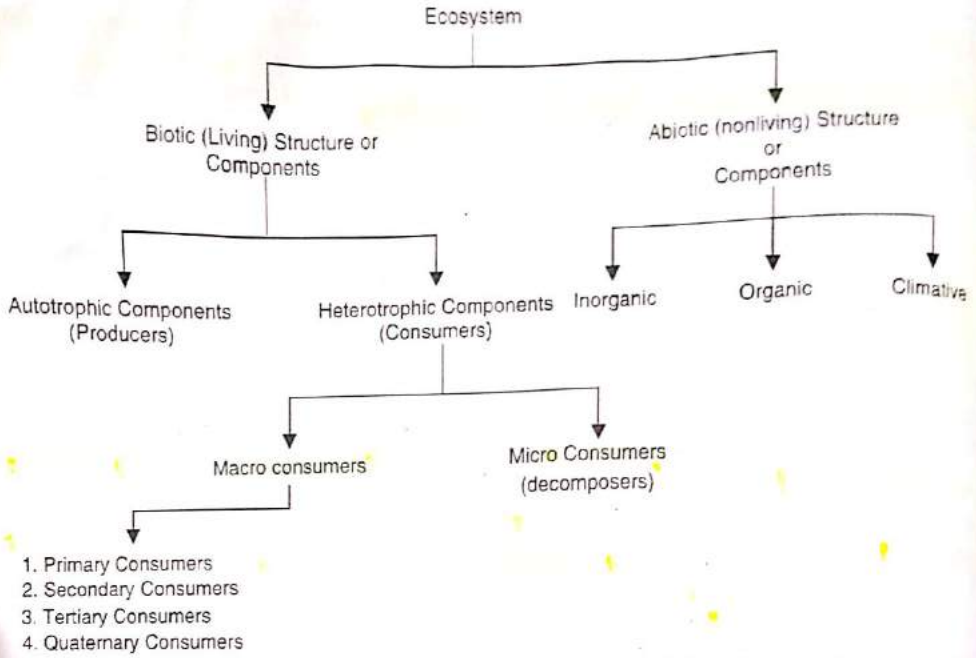
2. Temporary and Natural ecosystems. These are short lived but operate under natural conditions.

3. Artificial or Anthropogenic ecosystems. These are man-made like fishery tanks dams, croplands and space ecosystems also. Fish aquarium is also come under this head.

These typologies are determined not only by the species composition but also by the physiognomic characteristics and soil and climatic conditions.

STRUCTURE OF AN ECOSYSTEM

It is a description of the species of organisms that are present (including information on their life histories, populations and distribution in space). The structure of ecosystem provides information about the range of climatic conditions that prevail in the area, composition and organization of Biological Communities and Abiotic compounds constitute the structure of an ecosystem. According to *Odum*, from the trophic (Food) point of view, an ecosystem has the following components:



1. Biotic Structure. Producers, consumers and decomposers are components of biotic ecosystem. Living things are made of control and other chemicals with a lot of water added. Living organisms exchange expel convert, assemble, disassembles, organise and otherwise manipulate the constituents of earth, air and water. Biotic structure includes plants, animals and micro organisms present in an ecosystem. We have identified producers, decomposers and consumers are the basic components of biotic ecosystem. These can be distinguished on the bases of their source of energy and material.

(*a*) **Autrotrophic components** (Autotrophic = self nourishing)

In which the fixation of light, energy, the use of simple inorganic substances and manufacture of complex material predominates. These are also called **producers.**

(*b*) **Heterotrophic Components** (Heterotrophic = other nourishing)

These utilizes, rearranges and decomposes the complex materials synthesized by the autotrophs. The most intense heterotrophic activity takes place where the organic matter accumulates in the soils and sediments. These are also called **consumers.**

PRODUCERS

All green plants are producers. They are also called "**converters**" or "**transformers**". They are living members of the ecosystem that utilize sunlight as their energy source and single inorganic materials from soil, air and water to transform them by photosynthesis in to more complex energy rich chemicals as their own food. Producers are largely photosynthetic plants and their kind varies with the kind of ecosystem. In dense forest the trees are the most important producers. In lakes and ponds, the producers are rooted or large floating and microscopic plants (phytoplankton) usually the algae. They are also known as "**photo-autotrophs**" (*Photo = light, auto = self, troph = food*)

Recently, scientists have found ecosystems based on chemical energy at great ocean depth (more than a km), where there is no light. The producers in these systems are bacteria that are able to gain energy from the oxidation of H_2S that seeps from volcanic rents in the ocean. Since these organisms get their energy from chemical reactions rather than sunlight, they are called "**Chemotrophs**"

CONSUMERS — As we have seen earlier, consumers are heterotrophs, the living organisms which ingest other organism. They derive their food directly or indirectly from the producers. The food is then digested i.e. broken down to simple substances which are metabolized in the consumers body and released the waste product to the environment. Consumers are of following types—

(*i*) *PRIMARY CONSUMERS.*— These are also called 'HERBIVORES' which feed directly on the producers. They vary with the kind of ecosystem. For example a deer and giraffe is a primary consumer in forest ecosystem, while cow or a goat is in a grassland or crop ecosystem. Protozoans and certain crustaceans which feed floating algae are also primary consumers.

(*ii*) *SECONDARY CONSUMERS.*— They are also called "*CARNIVORES*" (meat eaters). For example insects gamefish in a pond eat primary consumers.

(*iii*) *TERTIARY CONSUMERS.*— In most of ecosystem some organism that eat other carnivores like — they are tertiary consumers.

(*iv*) *OMNIVORE.*— A person or animal eating plants and animals is called omnivores.

(*v*) *TOP CARNIVORES.*— Some ecosystem have animals like lion and vulture, which are not killed or rarely killed and eaten by other animals are called top carnivores.

(*vi*) *DETRITIVORES.*— These are the bottom living which subsist on the rain of organic detritus from autotrophic layers e.g. beetles, termites, ants crabs etc.

3. *DECOMPOSERS.*— They are also the living components, mainly bacteria and fungi which breakdown complex compounds of dead protoplasm of producers and consumers to simple organic compounds and ultimately in to inorganic nutrients. In all the ecosystems, this biotic structure prevails. Molds and mushrooms of the forest are the largest of the decomposers that are visible. The role of decomposers in ecosystem is very important. They are responsible for the completion of ecosystem mineral cycles. They are also called *microconsumers* or *saprobes* or saprophytes or saprotrophs. (Sapros = rotten, trophs = feeder) other examples are bacteria and fungi.

2. *ABIOTIC STRUCTURES OR COMPONENTS.*— The physical and chemical components of an ecosystem constitute its abiotic structure. It includes two things—

(*i*) *MATERIALS OR CHEMICAL FACTOR*—The materials are like water, minerals, atmospheric gases and other inorganic salts. They also include some organic matter such as amino acids, decay products, lipids, carbohydrates, proteins etc. The quantity of abiotic materials like the minerals present at any given time in an ecosystem is termed as the '*standing state*' or '*standing crop.*'

(*ii*) *ENERGY OR PHYSICAL FACTOR.* This is in the form of light, heat and stored energy in chemical bonds. Annual rainfall, wind latitude and altitude etc. are also some physical factors, which have a strong influence on ecosystem. For proper functioning of an ecosystem there must be a continuous 'flow of energy' and 'cycling of minerals' among the organisms of the ecosystem.

ENERGY FLOW IN THE ECOSYSTEM

Energy is needed for every biological activity. Solar energy is transformed in to chemical energy by a process of photosynthesis. This energy is stored in plant tissue and then transformed in to mechanical and heat form during metabolic activities. In the biological world the energy flows from sun to plants and then to all heterotrophic organisms like nitroorganisms, animals and man i.e. from producers to consumers. 1% of the total sunlight falling on the green plants is utilized in photosynthesis. This is sufficient to maintain all life on this earth. There is no 100% flow of energy from producers to consumers. Some is always lost to environment. Because of this, energy can not be recycled in an ecosystem '*it can only flow one way.*'

The flow of energy follows the two laws of thermodynamics.

Ist law of thermodynamics. The law states that energy can neither be created nor be destroyed but it can be transformed from one form to another. Similarly, as we have read earlier, solar energy utilized by green plants (Producers) in photosynthesis converted into biochemical energy of plants and later into that of consumers.

IInd law of thermodynamics. The law states that energy transformation involves degradation or dissipation of energy from a concentrated to a dispersed form. We have seen dissipation of energy occurs at every trophic level. There is loss of 90% energy, only 10% is transferred from one trophic level to the other.

SUN AS THE SOURCE OF ENERGY. Sun is the source of energy which extends radiations from high frequency to low frequency. Approximately 99% of total energy is in the region between UV and IR. The visible spectrum spreads over 0.38 μ to 0.77 μ involving about 50% of solar radiations. Some autotrophs however utilize energy released from oxidation processes for the synthesis of organic food.

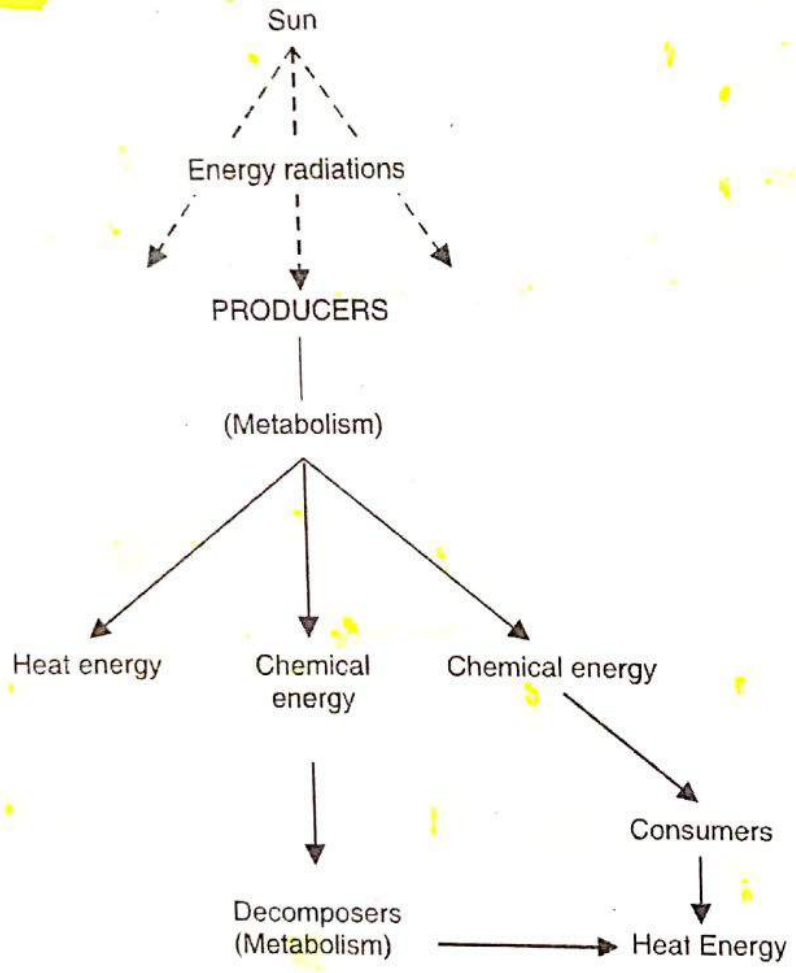


Fig 3.1 Sun as the source of energy

ENERGY FLOW MODELS

As we have seen, that there is unidirectional flow of energy from sun to the producers and then various types of consumers. Therefore, behaviour of energy in ecosystem can be termed **Energy flow**. About 34% of the sunlight reaching the atmosphere is reflected back in to its atmosphere. 10% is held by ozone layer, water vapours and other atmospheric gases. Rest 56% reaches the earth surface. Out of this 1-5% is used by green plants for photosynthesis.

$$6CO_2 + 6H_2O \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} C_6H_{12}O_6 + 6O_2$$

Rest is absorbed as heat by ground vegetation or water. The flow of energy in an ecosystem can be explained with the help of various energy flow models—

ECOLOGICAL SUCCESSION

Biotic communities are not static, they change with time. This change can be understood on several levels. Changes take place continuously in the community structure, organization, physiognomy, the associated animals and the environment at a place in the course of time, this phenomenon is called **ecological succession.** The rate of successional changes is rapid initially and gradually it slows until a point of dynamic equilibrium is reached, and the community is more or less stable. A complete succession is called a **SERE.** A sere is made up of a number of seral stages.

In any of the basic environments such as terrestrial, fresh water or marine, the succession may be of following two types—

(i) **PRIMARY SUCCESSION.** It is the process of species colonization and replacement in which the environment is initially virtually free of life, i.e. the process starts with base rock or sand deme or river delta or glacial debris and it ends when climax is reached. The sere involved in primary succession is called **PRESERE.** Primary succession occurs when a community begins to develop on a site previously unoccupied by living organisms.

(ii) **SECONDARY SUCCESSION.** The term secondary succession refers to community development on locations or sites previously occupied by well developed communities. It occures where a community has been disrupted and the surface is completely or largely devoid of vegetation. It may be due to earthquake, fire or even clearing of forests by man. In each case organism modify the environment in a way that allow one species to replace another. The sere involved in secondary succession is called **SUBSERE.**

Depending on the moisture contents, the primary and secondary successions may be of the following types—

(A) HYDRACH or HYDROSERE. The succession when starts in the aquatic environment such as ponds, lake, streams, swamps, bogs etc.

(B) MESARCH OR MESOSERE. It is an intermediate type with adequate moisture. The succession when begin in such an area is called mesarch.

(C) XERACH OR XEROSERE. The succession when starts in Xeric or dry habitat having minimum amounts of moisture, such as rocks, dry deserts etc is called xerach. A temporary community in an ecological succession on dry and sterile habitate is called Xerosere. It may be of three types—

(i) **LITHOSERE.** i.e. succession initiating on rocks.

(ii) **PSAMMOSERE.** i.e. succession initiating on sand.

(iii) **HALOSERE.** i.e. succession initiating on saline water or soil.

Some times succession is also classified into two on the basis of community metabolism.

(a) AUTOTROPHIC SUCCESSION. It is characterised by early and continued dominance of autotrophic organisms like green plants. It begins in a predominantly inorganic environment and the energy flow is maintained indefinitely.

(b) HETEROTROPHIC SUCCESSION. It is characterised by early dominance of heterotrops such as bacteria, actinomycetes, fungi and animals. It begins in a organic environment and there is a progressive decline in energy content.

FOOD CHAINS

A sheep may eat some grass and in turn it may be eaten by a person. The algae of a lake will be eaten by many Zooplanton, such as crustaceans and insect larvae. They are eaten by small fish and in turn they are eaten by bars, which may be caught by a bear. From all these examples it is clear that plants form the link between biotic and abiotic components of the ecosystem. They draw water and minerals from the soil and combine them with sunlight and carbondioxide from the air to make carbohydrates, fats, proteins, vitamins and usable minerals through photosynthesis.

Small harbivorous organisms such as Caterpillars field mice etc. Consume this vegetable material and convert it to animal material, which serve as food to meat eating animals. They are eaten by larger carnivores. This sequence of eaten and being eaten, with the resultant transfer of energy is known as **FOOD CHAIN.** Thus in food chains organisms of an ecosystem are linked together. Each step is known as **trophic level** and the study of the energy flow through these steps is called **trophic ecology.** Food chains are not isolated from each other.

Primary producers trap radiant energy of sun and transfer that to chemical or potential energy of organic compounds such as carbohydrates proteins and fats. When herbivore eats a plant and these compounds are oxidised. As we have read earlier the energy liberated is just equal to the amount of energy used in synthesizing the substances. When this animal is eaten by another one,

Other examples of food chains are :

1. Grass → Rabbit → Fox → Wolf → Lion.
   (Grass land ecosystem)
2. Phytoplanktons → Waterfleas → small fish → Tuna
   (Pond ecosystem)
3. Lichens → reindeer → Man
   (Arctic Tundra)

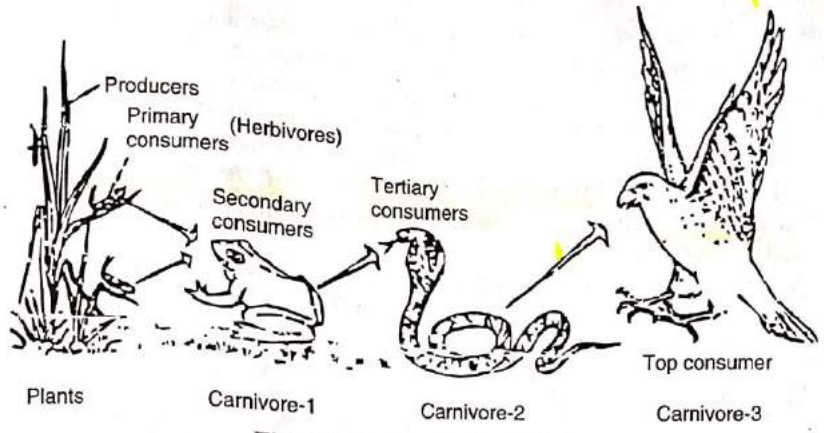


Fig. 3.5. Food and a food-chain

1. GRAZING FOOD CHAIN

This type of food chain starts from green plants and ends to carnivores by passing through herbivores. All examples cited above show this type of food chain. The primary carnivores or secondary consumers eat herbivores or primary consumers of the ecosystem. And likewise, secondary carnivores or tertiary consumers eat primary carnivores. The total energy assimilated by primary carnivores or gross tertiary production and its disposition in to respiration, decay and further consumption by other carnivores is entirely analogous with that of herbivores. Thus much of the energy flow in these chains can be described as follows —

Autorophs Primary producer → Herbivore Primary Consumer → Primary Carnivore Secondary Consumer → Secondary Carnivore / Tertiary Consumer → so on

2. DETRITUS FOOD CHAIN

The term **detritus** is given to organic wastes, exudates and dead matter derived from grazing food chain. The energy contained in this detritus is not lost to the ecosystem as a whole, rather it serves as the source of energy for a group of organisms (**Detritivores**), they differ from grazing food chain called the detritus food chain. These food chains are less dependent on solar energy, but chiefly depend on the influx of organic matter produced in another system. Such food chains operates in the decomposing accumulated litter in a temperate forest.

In some ecosystems, considerably more energy flows through the detritus food chains than through the grazing food chains. The organisms of the detritus food chains are, algae, bacteria, slime molds, fungi, actinomycetes protozoa, insects, mites, crustaceans, molluses worms, nematodes etc. Some species are highly specific in their food requirements and some can eat almost anything. All these are detritus consumers. They ingest large amounts of the vascular plant detritus. These animals are in turn eaten by some minnows and small game fish i.e. small carnivorus which in turn serve as food for larger game fish and fish eating birds i.e. top carnivores.

Heald (1969) and **Odum (1971)** have studied the detritus food chain of mangrove leaves (Rhizophora mangle) of Southern Florida. Conclusively, we can understand detritus food chain as follows —

Detritus → Detritivores → Detritivore Consumers → Small Carnivores → Large Carnivores

FOOD WEBS

In nature simple food chain occur rarely. The same organism may operate in the ecosystem at more than one trophic level i.e. it may derive its food from more than one source. Even the same organism may be eaten by several organisms of a higher trophic level or an organism may feed upon several different organisms of lower trophic level. In this way individual food chains interconnect to form a complex network with several linkages and are known as food web. Thus food web is defined as—**"A network of food chains where different types of organisms are connected at different trophic levels, so that there are a number of options of eating and being eaten at each trophic level.**

Fig. (3.7) shows the interlinking of five food chains in a terrestrial food web.

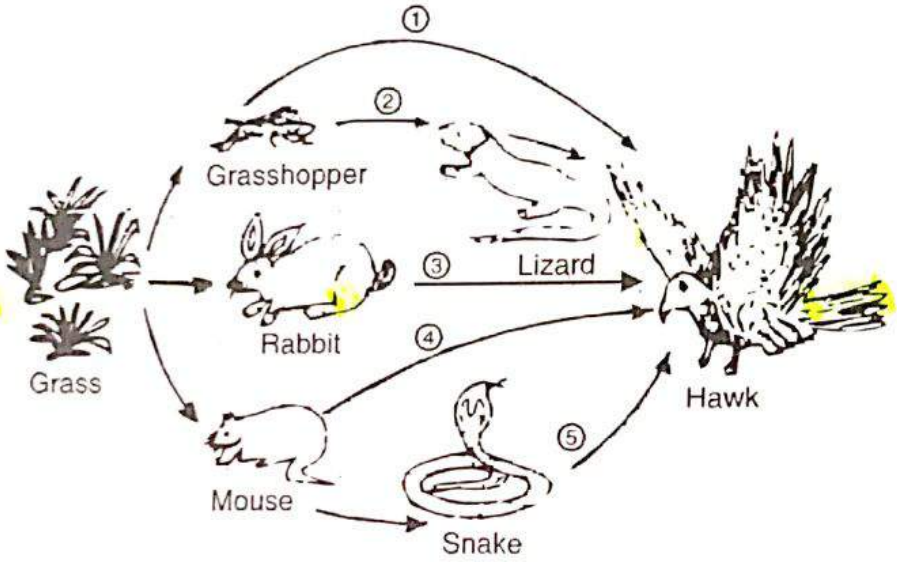


Fig. 3.7 A food web in a grassland ecosystem with five possible food chains.

The following five types of food chains are interconnected to form food web in this figure.

(1) Grass → Grasshopper → Predatory bird (Hawk)

(2) Grass → Grasshopper → Lizzard → Hawk.

(3) Grass → Rabbit → Hawk (or vulture or man)

(4) Grass → Mouse/Rat → Hawk

(5) Grass → Mouse/Rat → Snake → Hawk.

This shows, food chains in natural conditions never operate as isolated sequences but are interconnected with each other forming some sort of interlocking pattern (which is referred to as a food web).

ECOLOGICAL PYRAMIDS

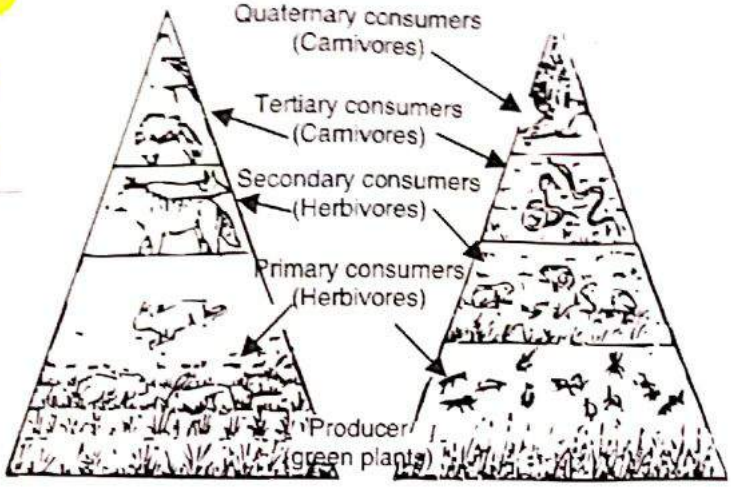
Charles Elton in 1927, noted that the animals at the base of the food chain are relatively abundant, while those at the end are relatively few in number i.e. there is progressively decrease in between the two extremes. Secondly, there is some sort of relationship between the numbers, biomass and energy content of the primary producers, consumers of the first and second orders and so on to top, Carnivores in any ecosystem. These relationships may be represented in diagrammatic (Graphic) ways and are referred to as **ecological pyramids or Eltonian Pyramids.**

Ecological pyramids are of three general types —

1. Pyramid of numbers - (Based on number of organisms at each level.)
2. Pyramid of Biomass - (Based on biomass of organisms.)
3. Pyramid of energy - (Showing the rate of energy flow and/or productivity at successive trophic levels.

The pyramids of numbers and biomass may be upright or inverted depending upon the nature of the food chain in the particular ecosystem whereas pyramids of energy are always upright.

1. Pyramid of numbers. This deals with the relationship between the number of producers, herbivores and carnivores at successive trophic levels. At the base of such figure (pyramid) is always the number of primary producers and the subsequent structures on this base are represented by the number of consumers at successive levels. In figure 3.8 a grassland ecosystem, the producers which are mainly grasses are always many in number. This number then shows a decrease towards apex, as the primary consumers or herbivores like rabbits are less in number than the grasses. The secondary consumers are lesser in number than primary consumers. Finally the top consumers (tertiary) like hawks or other animals are least in number. Thus the pyramid becomes upright. In a pond ecosystem, the pyramid is also upright.



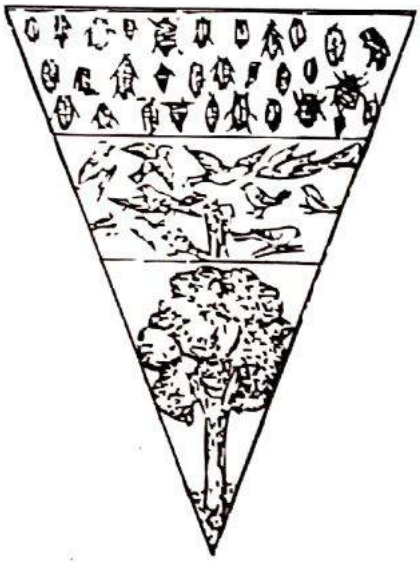
(Upright)

Fig. 3.8 Pyramids of Numbers

Here the producers which are mainly the phytoplanktons as algae, bacteria etc. are maximum in number, the herbivores which are smaller fish are lesser in number than producers. The secondary consumers are lesser in number than herbivores. Finally the top consumers (tertiary) are least in number.

In a forest ecosystem, however the pyramid is inverted, Fig. 3.9 illustrates an instance where the number of primary producers (a tree) is less than that of herbivore birds feeding upon the tree fruits. The number of parasites like bugs and lice living and feeding upon the birds body is still higher. Thus depending upon the size and biomass the pyramid of numbers may not be always pyramidal, it may even be completely inverted in shape.

Odum (1971) has studied the grassland and forest ecosystems by collecting the data from USA and England respectively.



(Inverted)

Fig.3.9 Pyramid of numbers

2. Pyramid of Biomass. Pyramids of biomass are comparatively more fundamental, as they instead of geometric factor, show the quantitative relationships. In order to explain the inverted nature of a pyramid of numbers, the idea of pyramid of biomass is given where the weight of primary producers forms the base. In figure 3.10 the ecosystem is shown where the pyramid of biomass is upright. The biomass of one tree is very high. The biomass of a number of birds feeding upon the tree is far less than that of the tree. Similarly, the biomass of even a very large number of parasite in and on the body of the birds is far less. Thus the pyramid of biomass, therefore, becomes upright. But there can be instances where the pyramid of biomass also get inverted as shown in figure 3.11. The biomass of phytoplanktons is quite negligible as compared to the small herbivores i.e. fish that feed on them. The biomass of large carnivores (Fish) feeding on small fishes is still higher. Harvery (1950) studied that in English Channel the biomass of primary producers is only 4 g/m^2 whereas that of the consumers is 21 g/m^2. This is the case in most aquatic bodies.

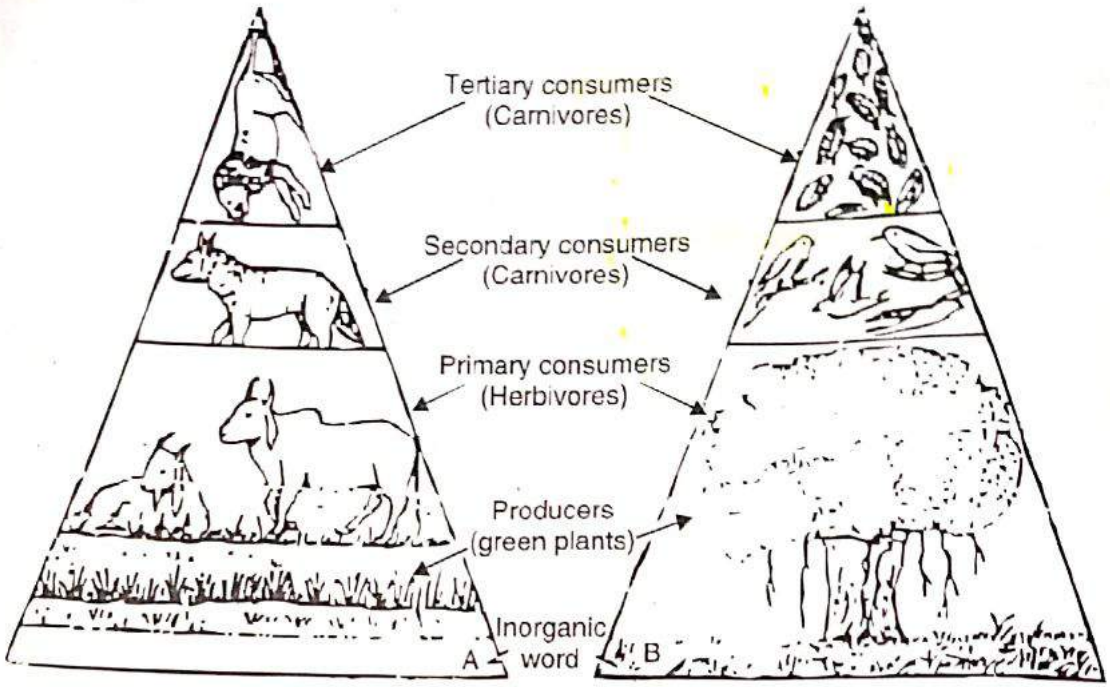


Fig. 3.10 Pyramids of Biomass

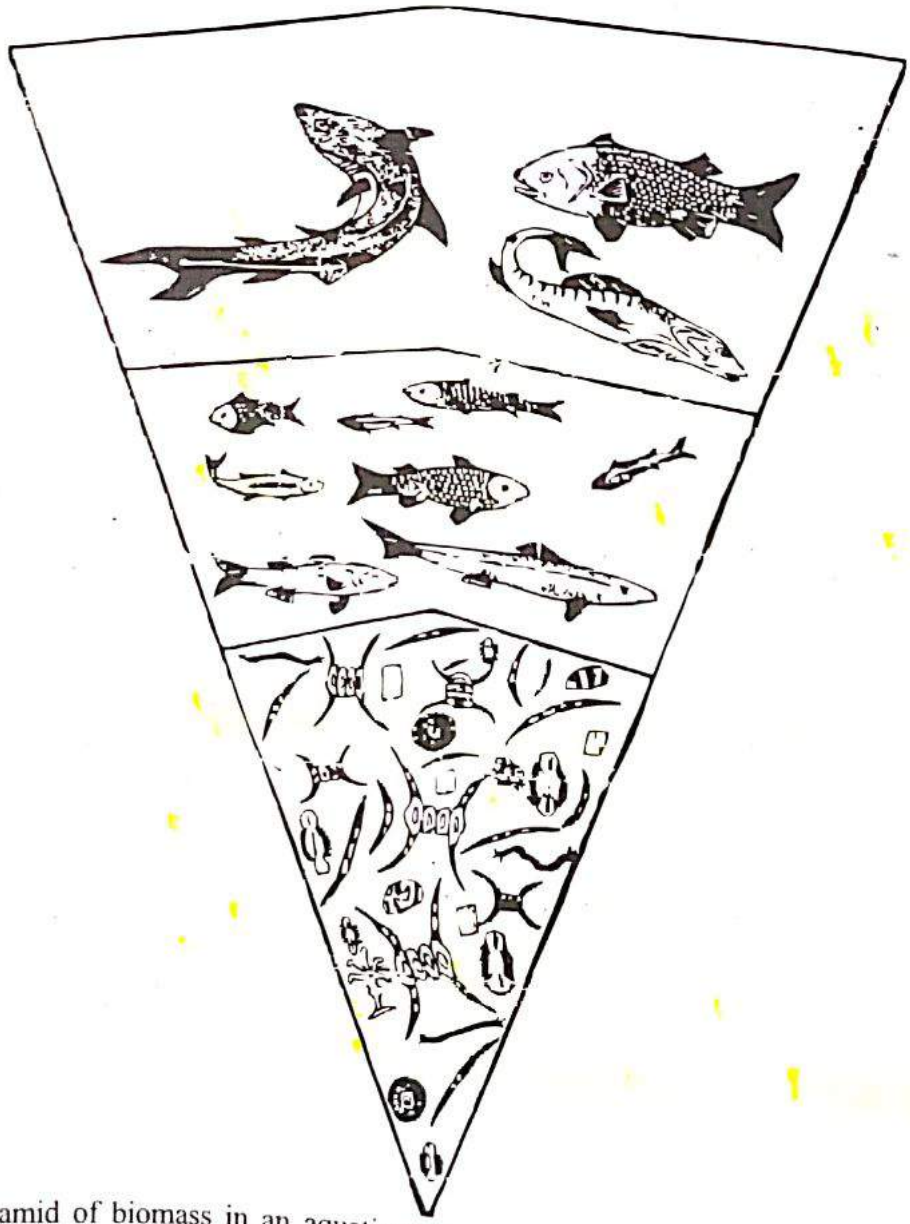


Fig. 3.11 Inverted pyramid of biomass in an aquatic ecosystem due to lower biomass of phytoplankt than of consumers in unit volume of water at any one time.

3. Pyramid of energy

Of the three types of ecological pyramids, the energy pyramid give the best picture of overall nature of the ecosystem. As against the pyramids of numbers and biomass the shape of the pyramid of energy is always upright, because in this the time factor is always taken in to account. The pyramid of energy represent the total quantity of energy utilized by different trophic level organisms of an ecosystem per unit area over a set period of time. The base upon which the pyramid of energy is constructed is the quantity of organisms produced per unit time or the rate at which food material passes through the food chain. Energy pyramids are always slopping (upright) because less energy is transferred from each level than was paid into it. In figure 3.12 organisms of the terrestrial and an aquatic ecosystems are shown. The quantity of the energy trapped by green plants in an area over a period is highest compared to that of organisms of other trophic levels and therefore the base of the pyramid

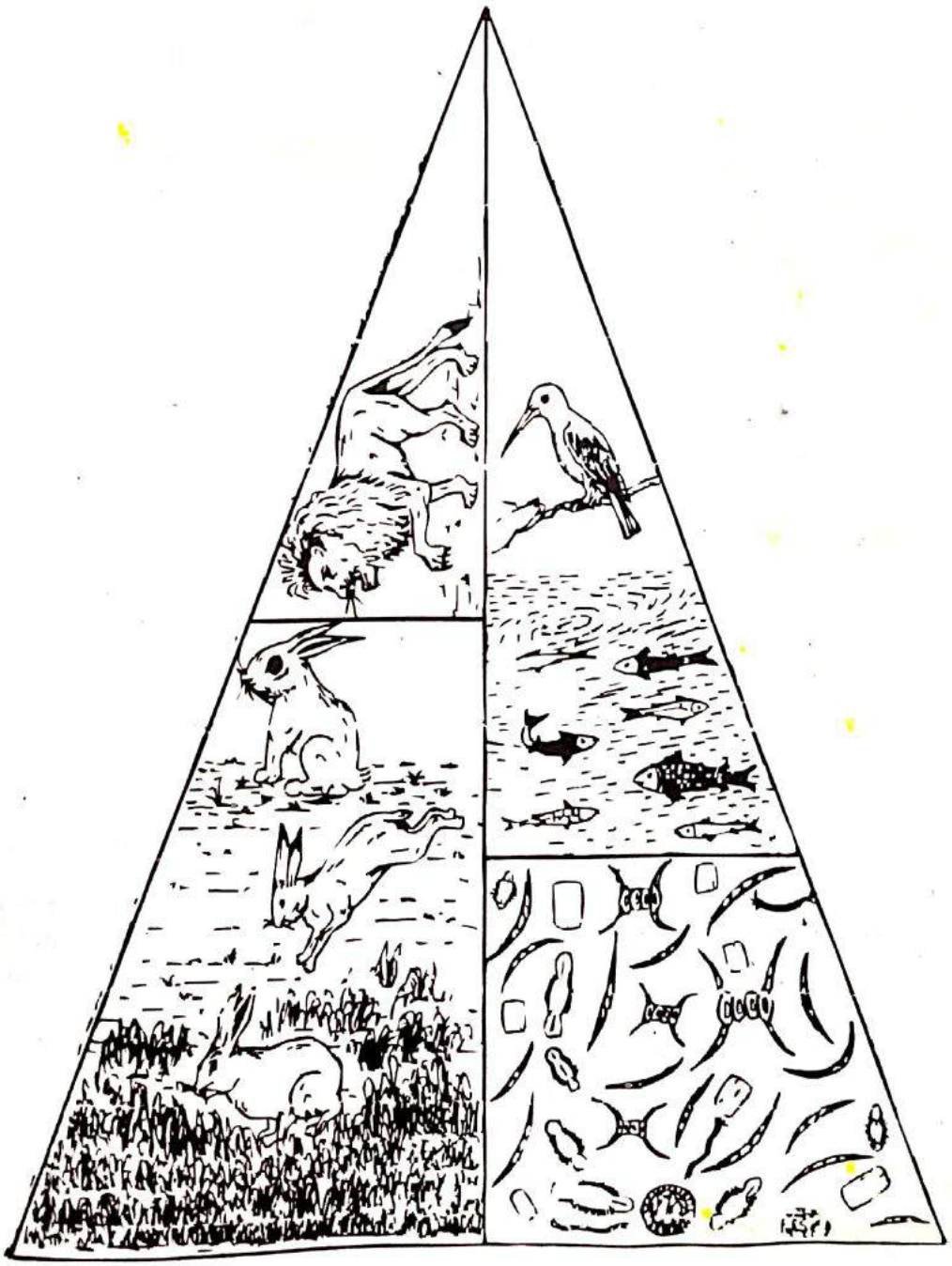


Fig. 3.12 Pyramids of energy in grassland and aquatic ecosystems. The cumulative energy contents utilized by primary producers is always higher as compared to energy utilization by successive trophic levels, over a period of time in a given area.

SOME MAJOR ECOSYSTEMS

There are three types of ecosystems in nature—

1. Terrestrial ecosystem
2. Freshwater ecosystem
3. Marine ecosystem

A large geographical are with its specific and complex flora and associated fauna is called a **biome.** The physical factors like, nature of soil, rainfall, temperature, light etc. effects the vegetation of a biome. The ecological characteristics of some major ecosystems are given.

Terrestrial ecosystems

The terrestrial ecosystems may be Latitudinal biome or altitudinal. It consists of

(*i*) Forest ecosystem
(*ii*) Grassland ecosystem
(*iii*) Desert ecosystem

FOREST ECOSYSTEM

Roughly 40% of the land is occupied by forest. But in India it is one-tenth. In India, tropical rain forests are found in Western Ghats, Andamans and North-East Himalayas. So these have maximum bio-diversity. The different components of a forest ecosystem are as:

Abiotic Component : These are the inorganic & organic substances present in the soil & atmosphere. In addition to the minerals present in the forests, we find the dead organic debris. The light conditions are different due to complex stratification in the plant communities.

Biotic Component : The living organisms present in the food chain occur in the following order—

1. Producers. These are mainly trees that show much species diversity and greater degree of stratification specially in tropical moist deciduous forest. In northern coniferous forest needle leaved evergreen tree, specially the spruces, firs and pines are with poor development of shrub and herb layers. Deciduous forest is greatly modified by man and much of it is replaced by cultivated and forest edge communities. Thus trees are of different kinds depending upon the kind of forest. Beside trees, shrubs and ground vegetation are also present. In these forests, producers are tectona grandis, butea frondosa, shorea rubusta and hagerstroemia parviflora. Plant dominants of the evergreen broad leaved forest range from the more northerly live oaks (Quercus virginiana) magnolias bays and hollies. Palms such as the sabal or cabbage palm are also often prominent vines and epiphytes are characteristic. In temperature deciduous forests the dominent trees are species of Quercus, Acer, Betula, Thuja, Picea etc.

2. Consumes. These are as follows—

(a) Primary Consumers : These are the herbivores that include the animals feeding on tree leaves as ants, flies, beetles, leafhoppers bugs, spiders etc. Many of the larger herbivorous vertibrates like moose, snowshoe have grouse are found on broad leaved developmental communities. Similarly some animals like elephants, nilgai, deer, moles, flying foxes, fruitbats, mongooses etc. are grazing on shoots and/or fruits.

(b) Secondary Consumers : These are the carnivores like snakes, birds, lizards, fox etc. feeding on herbivores.

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

3. Decomposers. These are wide variety of micro-organisms like actinomycetes (streptomyces), bacteria (Bacillus, clostridium, Pseudomonas etc.), Fungi (species of Aspergillus, Coprinus, Polyporus, Fusarium, Trichoderma etc.) Rate of decomposition in tropical and subtropical forests is more rapid than that in the temperate ones.

2. Grassland Ecosystem

This type of terrestrial ecosystem occupy roughly 19% of the earth surface. Grasslands dominated by grass species but some times also allow the growth of a few trees and shrubs. Rainfall is average but erratic. These are three types of grasslands depending upon climatic regions—

(i) Tropical grassland. Tropical Biomas (grasslands with scattered trees or clumps of trees) are found in warm regions with 40-60 inches of rainfall but with a prolonged dry season when fires are an important part of the environment. The largest area of this type is in Africa (Fig.3.13) but sizable tropical biomes or grassland also occur in South America and Australia. In Africa these are known as **Savannas.** Grasses belonging to such genera as Penicum, Pennisetum, Andropogon and Imperata. A view of this African Savanna country, including grass scattered trees and mammalian herbivores is in fig. 3.14.

(ii) Temperate grassland. In US and Canada, these grasslands are known as **prairies,** in South America as **pumpas**, in Africa as **Velds** and in Central Europe and Asia as **Steppes.** These occur where rainfall is too low (between 10 - 30 inches) to support the forest life form but is higher than that which results in desert life forms. However grasslands also occur in regions of forest climate where edaphic factors favor grass in competition with woody plants. Temperate grasslands generally occur in the interior of continents. In North America tall grass prairies have now been replaced by grain agriculture.

(iii) Arctic Tundra. There are two tundra biomes covering large areas of arctic, one in the Palearctic and other in the Nearctic region. In both continents the boundary between tundra and forest lies further north in the west where climate is moderated by warm westerly winds. The ground remains frozen except for the upper few inches during the open season. The permanently frozen deeper soil layer is called **permafrost.** The tundra is a wet arctic grassland consists of lichens, grasses, sedges and dwarf woody plants.

The various components of the grasslands are

Abiotic Components. The elements like C, H, O, N, P, S, etc. are supplied by CO_2, water, nitrates, phosphates, sulphates etc. present in soil & atmosphere. In addition, some other elements are also present in traces.

Biotic Components

(i) Primary Consumers. The herbivores feeding on grasses are grazing animals as cows, buffaloes, deers, sheep, rabbit, mouse etc. Besides them some insects like leptocorisa, dystercus, oxyrhachis, etc. termites and millipeds etc also feed on the leaves of grasses.

(ii) Secondary Consumers. The animals like fox, jackals, snakes, lizards, birds etc. (Carnivores) feed on herbivores.

Sometimes the hawks feed on secondary consumers.

Decomposers. The microbes active in the decay of dead organic matter are different species of fungi, some bacteria and actinonycetes. They bring about the minerals back to the soil, thus making them available to the producers.

DESERT ECOSYSTEM

Desert generally occur in regions having less than 10 inches of rainfall. Scarcity of rainfall may be due to—

(1) High subtropical pressure as in the Sahara and Australian desert.

(2) Geographical position in rain shadow

(3) High altitude.

About 1/3rd of our world's land area is covered by deserts. There are three life forms of plants that are adapted to deserts :

(*i*) The annuals, which avoid drought by growing only when there is adequate moisture.

(*ii*) The succulents, such as cacti, which store water

(*iii*) The desert shrubs

Based on the climatic conditions, deserts may be classified as

(*a*) Sahara, Namib in Africa, Thar, Rajasthan (India) are called **tropical desert,** which are driest.

(*b*) Mojave in Southern California is called **temperature desert** where days are very hot and cool in winters.

(*c*) Gobi desert in China is called **cold desert** where cold winters and warm summers.

The biotic components are

(1) Producers. As we have seen, these are shrubs bushes, some grasses and few trees. Some times, Cacti are also present. Some lower plants like lichens and Xerophytic mosses may also be present.

(2) Consumers. The most common animals are reptiles and insects. In addition to them, some nocturnal rodents and birds are also found. Camels "the ship of desert" feed on tender shoots of the plants.

(3) Decomposers. Due to poor vegetation, these are very few. They are some fungi and bacteria.

AQUATIC ECOSYSTEMS

More than 70% of the land is covered by water. The important ecosystems are

POND ECOSYSTEMS. Ponds are small bodies of water in which the littoral zone is relatively large and the limnetic and profundal regions are small or absent. Stratification is of minor importance. Ponds may be found in most regions of adequate rainfall. They are continually being formed, as a stream shift position, leaving the former bed isolated as a body of standing water where organic materials are accumulated.

Temporary ponds are dry for part of the year are specially interesting and support a unique community organisms in such ponds must able to survive in a dormant stage during dry period.

Ponds created by damming of stream or basin by man or by animals such as the bearer, are among the most numerous. In united states man made ponds were "mill ponds".

Ponds play an important role in the villages where most of the activities like washing clothes, bathing, swimming, cattle bathing etc. are centre around ponds. We may study the pond as an ecosystem by making its convenient division into some basic components as shown in fig. 3.15.

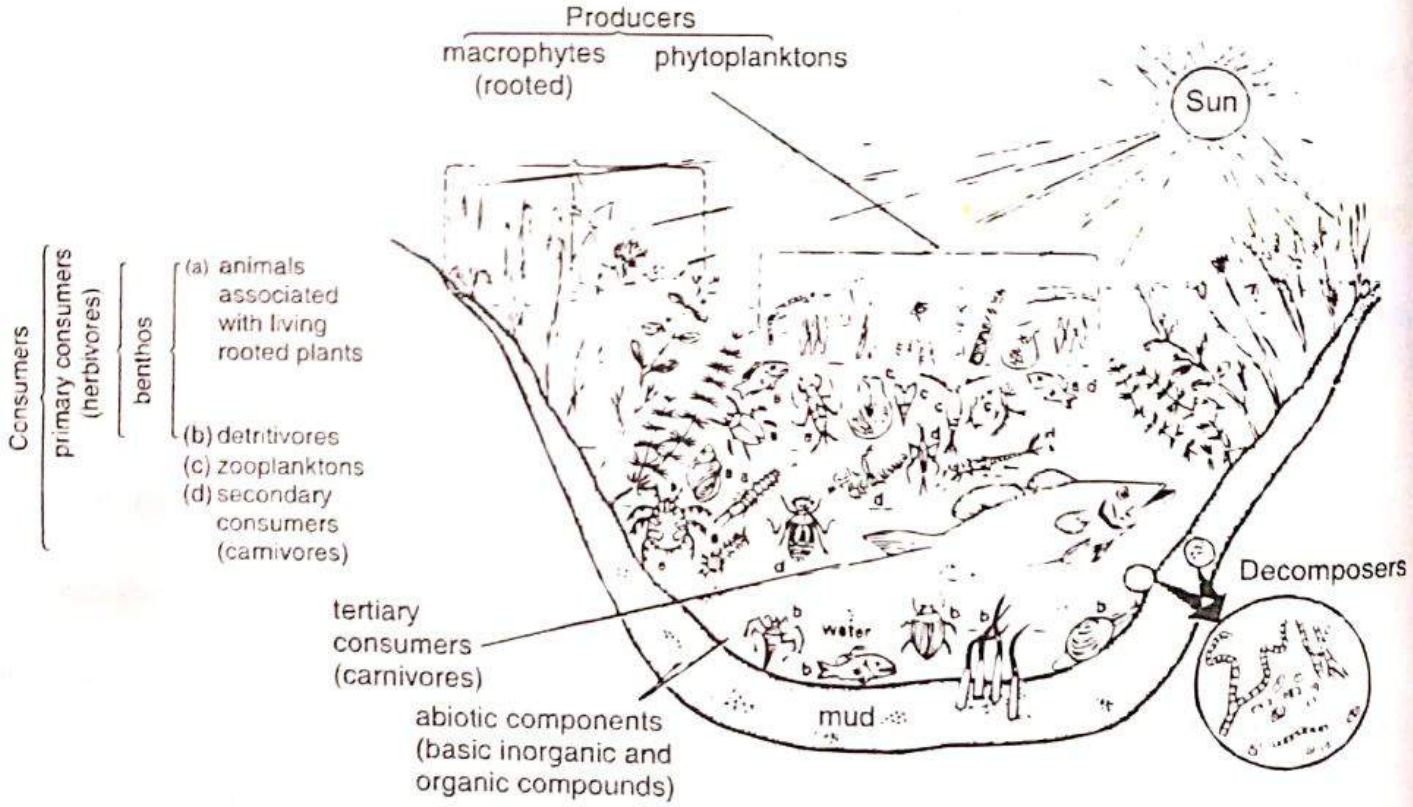


Fig.3.15 Diagram of pond ecosystem, showing its basic structural units—the abiotic (inorganic and organic compounds) and biotic (producers, consumers and decomposers) components.

These components are as

Abiotic Component. Apart from heat, light the basic inorganic and organic compounds, elements are water, CO_2, oxygen, calcium, nitrogen, phosphorus, amino acids etc. The amount of the minerals present at any time in the physical environment of the pond. "Standing state" may be estimated by appropriate methods. Light intensity and turbidity index of water at different depths can also be measured by lux-photometer and Sechhi disc respectively. pH of water and mud is determined by Electrical pH meter. DO, CO_2, phosphate, nitrogen, etc. can also be measured by appropriated methods. Carbohydrates, proteins, lipid etc. are also estimated for biomass determination.

Biotic Components They are as follows—

1. Producers. These are autotrophic, green plants and bacteria. They fix radiant energy and with the help of minerals from water & mud form complex organic substances like Carbohydrates, proteins & lipids. Producers are of the following types—

(a) Macrophytes. These are mainly rooted larger plants which include partly or completely submerged floating and emergent hydrophytes. The common species of the plants are Trapa, Typha, Sagittaria, Nymphaea, Chara, Hydrilla, Utricularia, Marsilea, Azolla, Sylvinia, Spirodella, Lemna etc.

(b) Phytoplankton. These are minute, floating or suspended lower plants like Ulothrix, Spirogyra, Cladophora, Oedogonium, Cosmarium, Eudorina Pandorina, Volvox, Chlamydomonas etc. and some flagellates. Biomass is estimated as weight of standing crop per unit area or volume. Generally, biomass and energy content of the vegetation decreases from the margin of the pond towards its centre. Energy content is generally expressed in terms of cal/gm dry wt.

2. Consumers. Most of the consumers are herbivores except insects and some large fish. But generally are heterotrophs. In pond consumers are distinguished as—

(*i*) **Primary Consumers.** These are herbivores, also known as "primary macro consumers" feeding directly on living plants. They may be large or in small size. They are further differentiated as—

(*a*) **Benthos.** These are the animals associated with living plants labelled as 'a' in fig and those bottom forms which feed upon the plants remains at the bottom labelled as 'b' in fig. Benthic population include fish, insect larvae, mites, molluses, crustaceans etc. Besides there some animals like cows, buffaloes and birds also visit the pond.

(*b*) **Zooplanktons.** These are chiefly the rotifers, (Brachionus, Lecane etc.), protozonas (Euglena, Coleps etc.) and Crustaceans (Cyclops, Stenocypris etc.). They feed on phytoplanktons lebelled as 'c' in fig.

(*ii*) **Secondary Consumers.** These are Carnivores like insects and fish which feed on primary consumers (herbivores) like Zooplanktons lebelled as 'd' in fig.

(*iii*) **Tertiary Consumers.** These are some large fish feed on smaller fish as shown in fig. In pond fish may occupy more than one trophic levels as shown in figure.

3. Decomposers. These are microconsumers, which absorb only a fraction of the decomposed matter. They decompose organic matter of both producers as well as microconsumers in simple forms. Thus they play an important role in return of mineral elements again to pond. The bacteria, actinomycetes and fungi (species Aspergillus, Cladosporium, Pythium, Penicillium, Circinella etc.) are most common decomposers in water and mud of the pond.

MARINE (OCEAN) ECOSYSTEM

The marine environment of seas and oceans is large occupying 70% of the earth surface. The volume of the surface area of marine environment lighted by sun is small in comparison to the total volume of water involved. All the seas are interconnected by currents, dominated by waves, influenced by tides and characterised by saline water. Each ocean indeed represents a very large and stable ecosystem. Oceans play an important role in regulating many biogeochemical and hydrological cycles, thereby regulating the earths climate. They have some major life zones i.e. coastal, Euphotic, Bathyal and Abyssal zones.

The **biotic components** of an ocean are as follows—

1. PRODUCERS

These are autotrophs, which are mainly the phytoplanktons. They trape radiant energy from sun through their pigments. A number of macroscopic seaweeds (Brown and red algae) are also come in this category. They are in distinct zones at different depths of water.

2. CONSUMERS

These are heterotrophic macroconsumers being dependent for their nutrition on the primary producers. These are

(*i*) The herbivores like Crustacions, molluscs, fishes etc. which feed directly on producers are called primary consumers.

(*ii*) The carnivores fishes like shad, herring etc. feeding on herbivores are called secondary consumers.

(*iii*) The top carnivores fishes like cod, haddock, halibut etc. that feed on secondary consumers are called tertiary consumers.

3. Decomposers.—The microbes active in the decay of dead organic matter are chiefly bacteria and some fungi.

Biodiversity and Its Conservation

INTRODUCTION

The term "Biodiversity" is short form of "Biological Diversity" and was coined by Walter G. Rosen in 1986 (Wilson 1994). According to Article-2 of Convention on Biodiversity (CBO). Biodiversity may be defined as, "Biological diversity means the variability among living organisms from all sources including, interalia, terrestrial, marine and other ecosystems and the ecological complexes of which they are part, this includes diversity within species between species and of ecosystem.

Biodiversity is neither the numbers of organisms present in any natural ecosystem nor a resource, but a property of living systems. According to Harvey B. Lillywhite (2002) it refers to "the variety and variability among living organisms and the ecological complexes in which they occur.

No one knows exactly how many species occur an our planet. Scientists believe that the total member of species on earth is in between 10 million to 80 million (Stork - 1988, Wilson 1988). We have been able to enlist only 1.4 million species so far. Nature has taken more than 600 million years to develop this exceedingly complex spectrum of life on this planet. The existence of human race depends on health and well being of other life forms in the biosphere.

Biological diversity is the total variety of life on our planet. Total number of races, varieties or species i.e. the sum total of various types of microbes, plants, animals present in a system is referred as *Biological diversity or simply as Biodiversity.*

GENETIC, SPECIES AND ECOSYSTEM DIVERSITY

Biodiversity is usually analysed at three levels i.e. species, genetic and ecosystem, each of which has its own significance.

1. Diversity of Biotic Communities and Ecosystems : Depending largely upon the availability of abiotic resources and conditions of the environment an ecosystem develops its own characteristic community of living organisms. A small pond, for example, constitutes an ecosystem and possesses a set of flora and fauna different from a river which is another type of ecosystem. Different types of forests, grass-lands, lakes, ponds, rivers, wet-lands etc. represent diverse ecosystems each with a characteristic biotic community.

2. Diversity of Species Composition within a Community : The biotic component in an ecosystem may be composed of a few species only or a large number of species of plants, animals and microbes, which react and inter-act with each other and with the abiotic factors of the environment. The richness of species in an ecosystem is usually referred to as **Species diversity.**

3. Diversity of Genetic Organization within a Species : Within a species there are often found a number of varieties or races or strains which slightly differ from each other in one, two or a number of characters such as shape, size, quality of their product, resistance to insects, pests and diseases, ability to withstand adverse conditions of environment etc. These differences are due to slight variations in their genetic organisation. This diversity in the genetic make up of a species is referred to as **Genetic diversity.** A species with a large number of races, strains or varieties is considered to be rich and diverse in its genetic

VALUES OF BIODIVERSITY

Biodiversity is a valuable natural resource for the survival of man kind. Man has domesticated a number of economically important plants and animal species. Old traditional varieties and the mid relatives of domesticated plants and animals constitute a vital genetic resource for us. Many plants and animals including wild life are of very important for human being. They can be used directly or indirectly to have consumptives, productive, social, ethical, aesthetic & ophons values i.e. in terms of money.

Consumptive value. Most of the developing countries obtain fuel wood from forests. Still more than 1500 million people cook their food by burning wood. About 1000 million cubic meter wood is used for fuel across the globe. This imposes heavy pressure on forests. Hunting of wild life, use of grass with some commercially important plants as fodder are of only comptive.

Various tribal societies fully depend on forests (biodiversity) for their habitation and livelihood. They used tubers, roots, fruits, seeds and meat of wild animals as their food.

Productive Value : Bamboos, grasses, canes, essential oils, tanning material, dyes, gums, resin, drugs, spices, poisons, insecticides, soap substitutes, rudraksha, lac, honey wax, tusser, Mahua seeds, Mahua flower and other seeds are forest products, they have their high commercial values. In addition to these, various herbs and animal body parts are sold in commercial market, both at national and international levels. Some benefits like, water quality, recreation, education, scientific research, regulation of climate etc. are indirect values to biodiversity that provide economic advantages to the people without consumption of the resource.

Some plants have been found to have immense medicinal properties, few of them with their curative properties are given below.

Name of medicinal plant	*Medicinal derivative*	*Curative property*
Cinchona	Quinine	Treatment of malaria
Isabgoal	husk and seeds of Isabgoal	Laxative, useful in chronic diarrhoea and dysentery
Opium poppy	Morphine, codeine and narcotine	Mental problems and cough
Brahmi	Juice of leaves and and stems	Repairs loss of memory
Ashwagandha (*Rauolfia serpentina*)	Serpentine	Urine problems
Basil (Tulsi)	Leaf-extract	Cough and cold, fever
Chalmogra	Seeds	Leprosy
Jambul	Bark-extract	Asthma and Bronchitis
Kalmegh	Root-extract	Liver tonic
Doob	Leaf-extract	Antiseptic

The lack of marketing facilities, lack of technical and financial support, involvement of middlemen in the business and large range of variation in the selling price of medicinal plants are keeping away farmers from the main trade.

Many pharmaceuticals have traditionally been derived from plants and animal sources. World-wide medicines from plants are worth over 40 billion dollars a year (Govt. of India 1991). Eighty percent of the people in tropical areas depend upon traditional medicines. Penicillin and tetracyclin and amongst the 3000 antibiotics extracted from micro-organisms. Guggal is an oleo-gum resin, long used in ayurvedic medicines for its anti-inflammatory, anti-rheumatic and hypo-cholesterolemic activity.

SOCIAL VALUES : Social value is one of the instrumental values where some thing has as a means to another's end. Materialistic uses of biodiversity are the core of instrumental values. The biodiversity has distinct social value attached with different societies. Goods and services provided by ecosystems to our society include

(1) Provision of food, fuel and fibber.

(2) Provision of shutter and building materials.

(3) Purification of air and water.

(4) Detoxification and decomposition of wastes.

(5) Generation and renewal of soil fertility, including nutrient cycling.

(6) Control of pests and diseases.

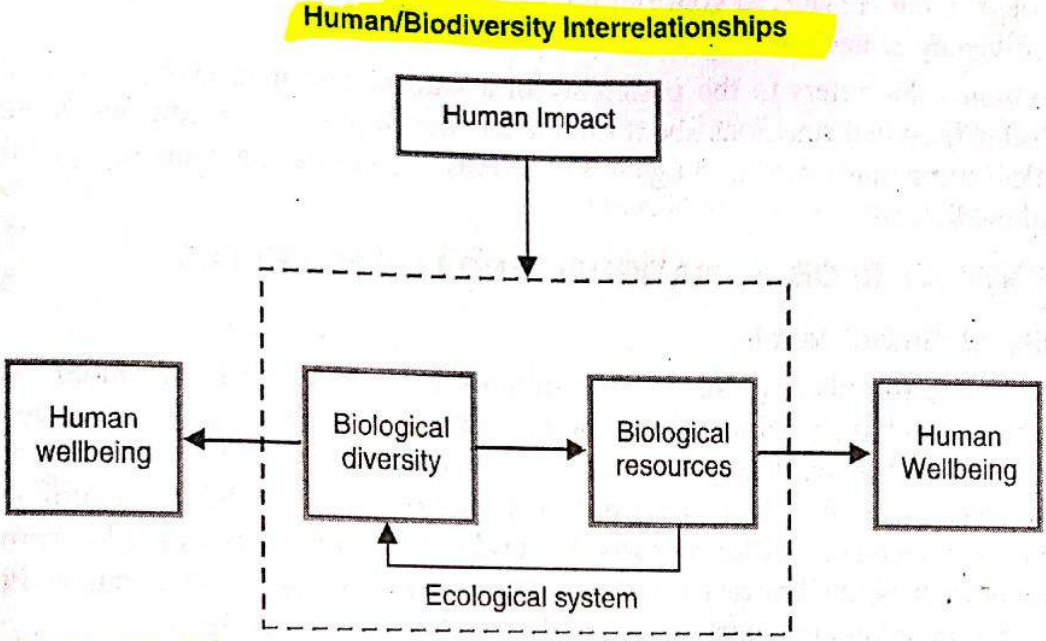
(7) Stabilization and moderation of earth's climate.

(8) Maintenance of genetic resources as key inputs to crop varieties.

(9) Live stock breeds, medicines and other products etc.

The charismatic species that have captured the public's heart and won their support for conservation. Biological resources are the pillars upon which we bind civilization. The loss of biodiversity threatens our existance i.e. social life. Thus protecting biodiversity is in our self interest.

These are the social values of biodiversity because biological resources provide the basis for life on earth including men. Fig. 4.1.



Ethical values : Ethical or religious values is also one of the indirect values of biodiversity. The ethical and religious value of biodiversity is rooted in the understanding that huminity is part of nature and that we are just one species among others. All species have an inherent right to exist. Future generations also have an inherent right to know them and to have the choice of using them or not.

Religions also have an significant impact on our attitude towards natural resources. The Buddhist perception of nature, for example, is based on different practices and approaches than that of Christian belief, though both are consistent with conserving biodiversity. Ethical value is one of the non-use values, which derive from human ethical considerations relating to matters such as the extinction of species and ecosystems.

Aesthetic value : The aesthetic value of biodiversity has been expressed in many ways through art, poetry, songs, literature, music and dance. Forests are closely linked with our relegion and culture. Human race has a great evolutionary attachment with forests as our ancestors lived in forests. Forests are nature's laboratories, where Scholars study natural sciences. Many types of trees are worshipped in tribal and Hindu societies i.e. Peepal, Bargad, Tulsi etc. Some animals like cow is worshipped by Hindus in all over India. In series of this many birds, colourful butterflies, mammals have great aesthetic value for human beings. Eco-tourism generate large amount of revenue annually that gives the aesthetic value of biodiversity. In this tourism people far and wide spend a lot of money and time to visit wilderness areas, where they enjoy the aesthetic value of diversity.

OPTION VALUES : Biological resources existed in this biosphere are very important for human beings. The option value of biodiversity suggests that any species may prove to be a miracle species. It is the precious gifts of nature presented to us. Option value is the indirect value of a species to provide an economic benefit to human society at some point in near future.

Option value is the value or a person's willingness to pay (WTP) to preserve the option of having an irreplaceable resource available for future use. The concept of option value had infinitive appeal, but was less defined. Attempts have been made to integrate option value into the main body of consumer theory. Most literature on option value is primarily concerned with technical issues such as the sign/direction. But few studies like Greenley et al 1981, Chopra 1993, Pearce and Moran 1994 on the topic show that option value for biodiversity is high. In this value, the insurance benefit that is provided to society through the protection that a resilient ecological system provided.

Biodiversity is natural capital, and therefore supplies a stream of value to current & future generations. Secondly lowers the risk of adverse outcomes. This too involves a future perspective in that the risks being considered confront both current & future generations. This is the option value of biodiversity protection.

The option value refers to the possibility of a natural resource having some value in the future. It is often used in discussions about finding and developing new medicines. More than 70% of the chemical compounds used in drugs in industrialised countries have the same or similar uses in traditional medicines.

HOT-SPOTS OF BIODIVERSITY

The explosive population growth is one of the prime causes of biodiversity loss (Soule – 1991). The most threatened of all biologically rich areas are called Hot-Spots. Scientists of Conservation have mapped 25 global biodiversity hot-spots. Hot-spots are identified by two main criteria, first plant endemism and then degree of threat. Within them, are housed at least half of the

THREATS OF BIODIVERSITY

One of the measure threat to Biodiversity is space, food and raw material for expanding human and plant establishment. Wilson 1985 described the losses of biodiversity as "*Crisis*", and this is more serious for developing countries like India. Since 1600 there have been over 1000 recorded extinctions of plants and animal species. (Smith et al 1993) Probably early humans were directly responsible for extinction of many large and smaller mammals. But the elimination of species is a normal process of the natural world. When species die or extinct, they will replace by others. Due to human population and its impact on ecosystems, thousands of species and sub-species become exinct every year. According to E.O.Wilson, we are losing 10,000 organisms a year i.e. 27 per day. If this will continue, we may destroy millions of plants, animals and microbes in next few decades. It is studied that 99% of all species of fossil that ever existed are now extinct.

Before man's appearance on this planet the rate of extinction was one species per thousand years. However, the pressure of human activity has drastically changed the picture. Between 1650 AD and 1950 AD about 30 species of higher animals were lost. Studies show that about 50,000

invertebrates species are losing every year. Almost one recorded as threatened. Indian wild life act 1972 schedule - I provides a list of about 150 endangered species. Disappearance of Dinosaurs along with about 50% of exististing species at the end of Cretaceous period is the best example of extinction. In India 33% of reptiles and 42% of bird species are endemic. It is said that, the current extinction rates are possibly 4 or 5 times more than the rates in the fossil record.

The following are the measure causes and issues related to threats to biodiversity.

HABITAT LOSS : Habit loss due to human activities and other disturbances are welknown factor. Varying human disturbances are changing ecosystems and are thus threatening the biodiversity. Due to habitat degradation wild populations become more volnerable to predators and diseases. This is especially true for wild life, which suffer due to habitat loss and fragmentation. Habitat loss is in instalments so that the habitat is divided into small and scattered patches i.e. *habitat fragmentation*. The natural forests and grasslands, which were the natural homes of thousands species including wild life species, are going cleared day by day for conversion into agriculture lands, pastures, settlements or for developmental projects. Thus these species are perished due to loss of their habitat.

Due to pollution and the presence of toxic and hazardous pollutants, our fresh water resources have suffered and many species of aquatic birds, fish and mammals have been threatened. Electric power plants, which causes thermal pollution in biosphere affected all aquatic communities and their natural food chains. Marine biodiversity is also under serious threat due to human intervention. If the present rate of deforestation continue, there will be loss of about 12% birds species and about 15% plant species in south and Central America (Simberloft 1984). Huge amount of habitat are lost each year as the world's forests are cut down. Rain forests, tropical dry forests, wet lands, mangroves and grasslands are threatended habitats and leading to desertification. Problems of acid rains and global climate change are also welknown for habitat loss.

POACHING OF WILDLIFE

Poaching is another threat to wildlife. As an ancient period, hunters, collectors, and smugglers (traders) are the measure threat to a number of species including endangered speices. They collected furs, hides, horns, tusks, and some live specimens, herbal products and smuggled to others for millions of dollars. The alarming point in this case is that for one animal they killed more than one. It is an illegal trade and internationally banned.

The cost of these animal parts are surprising. The cost of Bengal tiger coat is more than one lac dollars. South American ocelot cost more than 50,000 dollars, a single orchid cost more than 5000 dollars, horns of rhinoceros cost their weight in gold. These are some examples by which we can understand the situation of trading wildlife products, which is highly profit making for poachers.

Over collection and over exploitation are the main causes of disappearance of plants of scientific and medicinal value. The reduction of genetic diversity among the cultivated species drastically limit possibilities of creating new cultivar in the future, which could be disastrous for human race. It is advisable that do not purchase the parts and products made from wild animals specially endangered species.

MAN-WILDLIFE CONFLICTS

Struggle for existance. This is applicable for both, man and wild animal. Due to habit loss animals come out of the forest and destroy the crops later on they become danger to human being. Villagers and affected people kill them. There are so many cases of conflict between man and wild life. In these cases forest department could not pacify, resulted to lack of non co-operation for wild life conservation from affected people.

Animals are prone to infection when they are under stress. Animals held in captivity are also more prone diseases. The elephants and other wild animals suffer pain and turn violent when they

ENDANGERED AND ENDEMIC SPECIES OF INDIA

ENDANGERED SPECIES OF INDIA

According to Red Data Book and Botanical Survey of India about 427 endangered plant species are identified. This is about 20% of India's total floristic wealth of higher plants. Examples of endangered plants species occuring in the North - Eastern region including the eastern Himalayas are as—

Eastern Himalayas	Acer laevigatum, A. molle, Anglica nubigena, Bunium nothum, Carum villosum, Pimpinella wallichii (Northeastem region also), Panax pseudogineseng, Calamus inermis, Phoenix rupicola (Northeastern region also), Lactuca cooperi, Berberis affinis, Engelhardtia wallichyiana, Coptis teeta, Aquilaria agallocha (Northerastern region also). Boehmeria tirapensis.
Northeastern region	Heracleum burmanicum, Peucedanum sikkimensis, Pimpinella evoluta, P. flaccida, Trachelospermum auritum, llex embeloides, I. khasiana, I.venulosa, Amorphophallus bulbifer, A. sylvaticus, Dioscorea laurifolia, D. arbiculata, Hopea shingkeng Musa velutina, Hedychtum aurantiacum, H. gracilimum, H. dekianum, H. gratum. H. greenii, H. hookeri, H. marginatum, H. rubrum.

The array of biological resources including their genetic resources are renewable in nature or in similar *ex-situ* conservation with proper management can support human needs indefinitely. Thus, it is appropriate to treat these as the fundamental sources for sustainable development. Their perpetuation in the existing forms and to the extent feasible on existing basis is therefore, essential to suitable explore factors from such a big reservoir for tomorrow's need.

Wetlands are transitional zone that occupy intermediate position between dryland and open water. It is estimated that India has about 4.1 million of wetlands, including natural and man made. Wetlands harbour enormous diversity of floral and faunal species, many of which are endangered. Some of the endangered animal species are listed in table 4.4. In India the number of official endangered animal species has risen from 13 (In 1952) to 250 (now). Some Indian bustard crocodile, muskdeer, blue whale, black buck, chinkara, wolf, nilgai, ante lope, tiger, flamingo, pelican white crane etc. Coral reefs are also under great threat. A species said to be endangered when its number reduced to a critical level or whose habitats have been drastically reduced.

Table 4.4 Some Endangered Animal Species in Wet Lands

	Species	*Common name*	*Wetland*
1.	*Cervus eldii eldii*	Manipur brow-antlered deer or Sangai	Kalibul Iamjao National Prak
2.	*Dugong dugon*	Dugong	Gulf of Mannar Andaman and Nicobar Islands
3.	*Cervus duvaucelii*	Swamp-deer or barasingha	Wetlands in Terai Assam
4.	*Prionailurus viverrinus*	Fishing cat	Swamps of Terai Himalayas, Sunderbans

5.	*Platanisia gangetica*	Gangetic dolphin	Ganges, Chambal and Brahmaputra rivers
6.	*Rhinoceros unicornis*	Indian one-horned rhinoceros	Kaziranga National Park, Manas
7.	*Bubalus bubalis*	Water buffalo	Kaziranga National Park
8.	*Panthera tigris*	Bengal tiger	Sunderban National Park
9.	*Anser indicus*	Bar-headed goos	Wetlands of Ladakh
10.	*Grus leucogeranus*	Siberian crane	Keoladeo Ghana National Park
11.	*Houbaropsis Bengalensis*	Bengal florican	Wetlands of Manas National Park
12.	*Francolinus gularis*	Swamp Partridge	Wetlands of Manas National Park
13.	*Ceryle lugubris*	Crested Kingfisher	
14.	*Leptoptilos dubius*	Greater adjutant stork	
15.	*Leptoptilos javanicus*	Lesser adjutant stork	
16.	*Ardea insignis*	White-bellied heron	Rivers of Assam and Arunachal Pradesh
17.	*Phoeniconaias minor*	Asian lesser flemingo	Rann of Kutch, Sundarbans
18.	*Carina scutulata*	While-wingled wood duck	Assam and Arunachal Pradesh
19.	*Megapodius nicobarensis*	Megapode	Nicobar Islands
20.	*Anas gibberifrons albogularis*	Andaman grey teal	Andaman Islands
21.	*Crocodylus palustris*	Marsh crocodile or Mugger	Hiran lake in Gir National Park
22.	*Gavialis gangeticus*	Gharial	National Chambal Wildlife Sanctuary
23.	*Crocodylus porosus*	Estuarine crocodile	Bhitarkanika Wildlife Sanctuary
24.	*Lepidochelys olivacea*	Olive ridley turtle	
25.	*Dermochelys coriacea*	Leather back turtle	Andaman and Nicobar Islands

Endemic — Species the plants or animals that exist only in one geographic region.

Some important plants which have medicinal, ornamental, forestry, economical, scientific etc. values are also in endangered conditions due to their over exploitation.

ENDEMIC SPECIES OF INDIA

Endemism of India biodiversity is significant. About 4,900 species of flowering plants are 33% of the recorded floras are endemic to the country. These are distributed over 141 genera belonging to 47 families. These are concentrated in the floristically rich areas of North East India, the Western Ghats, North West Himalayas and the Andaman and Nicobar Islands.

The Western Ghats and the Eastern Himalayas are reported to have 1,600 and 3,500 endemic species of flowering plants, respectively. These constitute two of 18 hot spots identified in the world. It is estimated that 62% of the known amphibian species are endemic to India of which a majority occur in Western Ghats. Nearly 50% of the lizards found in India are endemic with a large number being found in Western Ghats.

Endemic species are the plants, which are limited in their distribution i.e. they are restricted to a small area and not found elsewhere in the world. It may be due to

- Poor adaptability of a species in a wide range of ecological
- Presence of some geographical barrier,e.g. Sea, Mountains etc.
- Failure of dispersal of reproductive organs (propagules, seeds, runners etc.)
- The species might have been comparatively young and not have enough time to spread.

Some examples of endemics include *Metasequoia* living gymnosperm endemic in China, *Sequoia* (red wood tree) endemic in coastal valleys of California, USA, *Primulla* and *Potentilla,* at high altitudes of Himalayas, *Ginkgo biloba* endemic in Japan and China.

Some of the endemic species in India are listed in table 4.5 :

WHAT IS EX-SITU CONSERVATION

"Ex-situ" conservation : It means the wild-life conservation in captivity under human care. In this, the endangered plants and animals are collected and bred under controlled conditions in gardens, zoos, sanctuaries etc. wild-life management in captivity have the following advantages :

(*i*) The organisms are assured of food, water, shelter and security and hence can have longer life span and longer span of breeding activity, thereby increasing the possibility of having more number of offsprings.

(*ii*) The chances of survival of endangered species increase because of human care under secure conditions.

(*iii*) This offers the possibility of using genetic techniques to improve the species concerned.

However, there are some disadvantages and limitations of wild-life management in captivity :

(*i*) Since maintenance and breeding of plants and animals under captivity is very expensive, it can be adopted only for a few selected species.

(*ii*) Wild-life captivity only under a set of favourable environmental conditions deprives the organisms the opportunity to adopt to ever-changing natural environment. Therefore, new life forms cannot evolve and thus the gene-pool gets stagnant.

WHAT IS IN-SITU CONSERVATION

In-situ means in the natural, original place or position, as in the location of the explant on the mother plant prior to excision. In-situ conservation which include conservation of plant and animals in their native ecosystems or even in man made ecosystem, where they naturally occur. This type of conservation applies only to wild fauna and flora and not to the domesticated animals and plants, because conservation is achieved by protection of populations in nature. This method of conservation mainly aims at preservation of land races with wild relatives in which genetic exists and/or in which the weedy/wild forms present hybrids with related cultivars. These are evolutionary systems that are difficult of plant breeders to stimulate and should not be knowingly destroyed.

The in-situ conservation of habitats has received high priority in the world conservation strategy programmes launched since 1980. Institutional, arrangement, especially in countries of the developing world, have been emphasized. This mode of conservation has some limitations however; there is risk of material being lost due to environmental hazards. Further the cost of maintaining a large portion of available genotypes in nurseries or fields may be extremely high.

In-situ conservation includes a system of protected areas of different categories e.g. National parks, Sanctuaries, National Monument, Cultural landscapes, Biosphere Reserves etc. One of the best methods to save wildlife species, which is on the road to extinction, is to put it in a special enclosure to reproduce. Sanctuaries and National Parks, whose legal definition varies from country to country, best illustrate this.

NATIONAL PARKS, WILDLIFE SANCTUARIES AND BIOSPHERE RESERVES

National Parks or a Sanctuary may be defined *as an area, declared by state, for the purpose of protecting, propagating or developing wild life therein, or its natural environment for their scientific, educational and recreational value. Human activities like hunting, firewood, collection, timber harvesting etc. are restricted in these areas.*

The creation of National Parks, Wildlife Sanctuaries and Biosphere Reserves is an attempt to manage wildlife by defining protected areas. Wildlife therein is regularly monitored and necessary management strategies for their perpetuation and preservation are formulated and implemented. These protected areas not only benefit wildlife, but indirectly humans too. Their protection means the protection of entire ecosystem, which is necessary to continue to enjoy the benefits that we may now receive from it.

A National Park is an area dedicated to conserve the scenery (or environment) and natural objects and the wildlife therein. In national parks, all private rights are non-existent and all forestry operations and other usages such as grazing of domestic animals are prohibited. However, the general public may enter it for the purpose of observation and study. Certain parts of the park are developed for tourism in such a way that enjoyment will not disturb or scare the animals.

Sanctuaries are also of range between 100 sq. kms to 500 sq. kms. The boundaries of sanctuaries are often not well defined. Controlled biotic interference is permitted in sanctuaries which allow tourist activities as well.

The national reserve or biosphere reserve are usually large protected areas with boundaries circumscribed by legislation and are usually more than 5000 sq. kms in area. Except for a limited degree of biotic interference is permitted in biosphere. Here due attention is accorded to research and conservation of gene pool.

Table 4.6 : Important National Parks and Wildlife Sanctuaries in India

States	*National Parks and Wildlife Sanctuaries*
Andhra Pradesh	Pakhal Wildlife Sanctuary, PocharamWildlife Sanctuary, Kawal Wildlife Sanctuary, Kolleru Pelicanary
Arunachal Pradesh	Namidapha Wildlife Sanctuary*
Assam	Kaziranga National Park*, Manas Wildlife Sanctuary*
Bihar	Hazaribagh National Park, Betla National Park
Goa	Mollen Wildlife Sanctuary
Gujarat	Gir National Park, Velavadar National Park, Wild Ass Sanctuary, Nal Sarovar Bird Sanctuary
Haryana	Sultanpur Lake Bird Santuary
Jammu & Kashmir	Dechigam Wildlife Sanctuary
Karnataka	Bandipur National Park*, Nagarhole National Park, Ranganthitto Bird Santuary*, Silent Valley National Park
Kerala	Periyar Wildlife Sanctuary*, Wynad Wildlife Sanctuary
Madhya Pradesh	Kanha National Park*, Shivpuri National Park, Bandhavgarh National Park*, Panna National Park

Maharashtra	Tadoda National Park, Yawal Wildlife Sanctuary
Manipur	Keibul Lamjao National Park
Meghalaya	Balpakram Sanctuary
Mizoram	Dampa Wildlife Sanctuary
Nagaland	Intangki Wildlife Sanctuary
Orissa	Simlipal National Park*, Chilka Lake Bird Sanctuary
Punjab	Abohar Wildlife Sanctuary
Rajasthan	Ranthambore National Park*, Sariska Wildlife Sanctuary*, Ghana Bird Sanctuary
Sikkim	Kanchenjuga National Park
Tamil Nadu	Mudumalai Widlife Sanctuary, Vedanthangal Water Bird Sanctuary
Uttar Pradesh	Corbett National Park*, Rajaji National Park, Dudhwa National Park*
West Bengal	Jaldapara Wildlife Sanctuary

Table 4.7 : Biosphere Reserves in India

Biosphere Reserves	*State(s)*
Nilgiris	Tamil Nadu, Kerala and Karnataka
Namdapha	Arunachal Pradesh
Nanda Devi	Uttar Pradesh
Uttarkhand (Valley of Flowers)	Uttaranchal
North Islands of Andamans	Andmans & Nicobar
Gulf of Mannar	Tamil Nadu
Kaziranga	Assam
Sunderbans	West Bengal
Thar Desert	Rajasthan
Mannas	Assam
Kanha	Madhya Pradesh
Nokrek (Tura range)	Meghalaya
Little Rann of Kutch	Gujarat
Great Nicobar Island	Andmans & Nicobar

Environmental Pollution

AIR POLLUTION

INTRODUCTION

According to U.S Public Health Service, "Air pollution may be defined as the presence in the outdoor atmosphere of one or more contaminants or combination thereof in such quantities and of such duration as may be, or may tend to be injurious to human, plant or animal life, or property, or which unreasonably interfere with the comfortable enjoyment of life, or property, or the conduct of business."

The atmosphere is a dynamic system, which steadily absorbs various pollutants from natural as well as man-made sources, thus acting as a natural sink. Gases such as CO, CO_2, H_2S, SO_2, and NO_x as well as particulate matter, such as sand and dust, are continually released into the atmosphere through natural activities such as forest fires, volcanic eruptions, decay of vegetation, winds and sand of dust storms. Man-made pollutants e.g., CO_2, NO_x, SO_2, CO_2, hydrocarbons, particulates etc are also released into the atmosphere. These have surpassed the pollutants contributed by nature thousand-fold. The magnitude of the problem of air-pollution has increased alarmingly due to population explosion, industrialization, urbanization, automobiles and others for greater comfort. The pollutants travel through the air, disperse and may interact with other substances in the atmosphere before they reach a sink, such as an ocean or a human receptor. If the pollutants enter the atmosphere at a faster rate than are absorbed by the natural sinks, then they gradually accumulate in the air. Such a disturbance in the dynamic equilibrium in the atmosphere by the air pollutants released by anthrapogenic activities resulting in considerable accumulation in the atmosphere may affect the very life on earth and its environment. Further, the dilution and dispersion of the gaseous pollutants in the atmosphere depend upon the meteorological conditions prevailing at a given time.

CLASSIFICATION OF AIR-POLLUTANTS

The air pollutants may be classified in different ways as follows:

(*a*) According to origin:

(*i*) Primary pollutants which are directly emitted into the atmosphere and are found as such, e.g., CO, NO_2, SO_2 and hydrocarbons.

(*ii*) Secondary pollutants which are derived from the primary pollutants due to chemical or photo-chemical reactions in the atmosphere, e.g., Ozone, Peroxy- acyl nitrate (PAN), Photo-chemical smog, etc.

(b) According to chemical composition:

(*i*) Organic pollutants, e.g.,-Hydrocarbons, aldehydes, ketones, amines and alcohols

(*ii*) Inorganic pollutants

Carbon compounds (e.g., CO and carbonates)

Nitrogen compounds (e.g., NO_x and NH_3)

Sulphur compounds (e.g., H_2S, SO_2, SO_3 and H_2SO_4)

Halogen compounds (e.g., HF, HCI and metallic fluorides)

Oxidising agents (e.g., O_3)

Inorganic particles (e.g., fly ash, silica, asbestos and dusts from transport, mining, metallurgical and other industrial activities).

(c) According to state of matter :

(*i*) Gaseous pollutants which get mixed with the air and do not normally settle out, e.g., CO, NO_x and SO_2.

(*ii*) Particulate pollutants which comprise of finely divided solids or liquids and often exist in colloidal state as aerosols, e.g.,- smoke, fumes, dust, mist, fog, smog and sprays.

Biochemical effects of some important air pollutants

1. Oxides of Sulphur (So_x)

SO_x comprises of SO_2 and SO_3. They are Colourless, heavy water soluble with pungent and irritating odour. SO_x pollution is due to volcanic activity, combustion of fuels, Coal fired power stations, transportation, Refineries, metallurgical operations, chemical plants and other natural and human activities. In atmosphere, oxidation of SO_2 in to SO_3 by photolytic and Catalytic processes (in presence of O_3, NO_x or hydrocarbons) giving rise to the formation of photochemical smog. In humid conditions of the atmosphere SO_3 reacts with water vapours to produce droplets of H_2SO_4 aerosols, give rise to the so called "Acid Rain".

$$SO_2 + O_3 \ \lambda \rightarrow SO_3 + O_2$$

$$SO_3 + H_2O \ \lambda \rightarrow H_2SO_4$$

Biochemical effects: Absorbs quickly and irritates the upper respiratory tract. Reacts with cellular constituent chemicals e.g., enzymes. The H_2SO_4 formed lowers pH, impairs enzymatic functions and destroys various functional molecules. Leads to bronchial spasms, breathlessness, impaired pulmonary function via airway resistance, impaired lung clearance and increased susceptibility for infection.

2. Oxides of Nitrogen (NOx)

Characteristics: NOx mostly comprises of NO, NO_2 and N_2O. NO is colourless gas and is slightly soluble in water. NO_2 is reddish brown gas, somewhat water-soluble, oxidizing agent, can react with water to form HNO_3 which is a powerful oxidizing agent and capable of reacting with almost all metals and many organic compounds. NO_2 can travel into the respiratory system. It is also involved in the formation of ozone in the atmosphere.

Biochemical effects: Oxidises cellular lipids, Forms bonds with haemoglobin and reduces the efficiency of oxygen transport. Disrupts some cellular enzyme systems. Higher levels and prolonged exposures may cause pulmonary fibrosis, inflammation of lung tissues and may eventually lead to death. Causes nitric acid mediated effects some of which are similar to that of H_2SO_4 described above. NO can form addition compound with haemoglobin, if it enters the blood stream.

3. Carbon monoxide (CO)

Characteristics: Colourless, odourless, toxic gas, slightly water soluble but still is extremely dangerous because it has a greater affinity for haemoglobin than that of O_2.

Biochemical effects : It competitively inhibits combination of O_2 and haemoglobin. It attacks haemoglobin and displaces O_2 to form carboxyhaemoglobin, and thus reducing the oxygen carrying capacity of blood.

(Under normal conditions) : $O_2 + Hb \xrightarrow{\lambda} O_2Hb$

(oxyhaemoglobin)

(In presence of CO) : $O_2Hb + CO \xrightarrow{\lambda} CO\,Hb + O_2$

(Carboxyhaemoglobin)

The immediate response to CO-poisoning is loss of judgment, which is responsible for many automobile accidents. Further exposure to higher levels of CO leads to various metabolic disorders such as asphyxiation and causes death. CO-poisoning can be cured by providing fresh O_2' which reverses the above reaction.

4. Ozone (O_3) and other photochemical oxidants such as peroxyacetyl nitrate (PAN) present in photochemical smog.

Characteristics : Ozone is a pale blue gas, fairly water soluble, unstable, sweetish odour. Very reactive oxidizing agent capable of combining with many organic compounds in cells and tissues as well as with rubber and other materials. O_3 and PAN are harmful to plants, animals and humans.

Biochemical effects : Oxidize cellular constituents. PAN and ozone toxicity is produced via generation of free radicals. The free radicals produced may damage DNA and thus alter cellular genetic integrity too. The toxic effects of ozone are manifested after inhalation and absorption in the lungs causing accumulation of fluids in the lungs (pulmonary edema), damaging lung capillaries and mortality if continued or high level exposures occur. Both O_3 and photochemical smog cause irritation of the eyes and respiratory tract. The free radicals produced by O_3 and other photochemical oxidants attack the sulphydryl groups on the enzymes and also inactivate enzymes like isocitric dehydrogenase, malic dehydrogenase and glucose-6-phosphate dehydrogenase, which are so much involved and essential for citric acid cycle and generation of cellular energy. O_3 may also inhibit the activity of some enzymes involved in synthesis of cellulose and lipids in plants. Among the sulphur containing amino-acids, cysteine is strongly attacked by PAN.

5. Hydrocarbons (and other volatile organic compounds)

Characteristics: Very reactive. React with many kinds of compounds yielding many kinds of products. Volatile hydrocarbons and other organic compounds participate in atmospheric reactions generating ozone.

Biochemical effects : Some of these compounds can react with the constituents of the cells. Carcinogenic hydrocarbons like benzopyrene can react with DNA causing mutations and cancer.

6. Particulate Matter

Characteristics : Solid particles or liquid droplets including fumes, smoke, dust and aerosols. Solid particular can adsorb various chemicals.

Biochemical effects : Effects vary with the nature of the particles. Carbon particles and other particles cause scarring of lungs via complex walling off and fibrogenic reactions leading to a disease condition known as "pneumoconiosis". Particles carrying absorbed mutagens lead to damage of DNA in the lungs and elsewhere.

Pulmonary fibrosis in asbestos mine workers, black lung disease in Coal miners and Emphysema in urban populations are attributed to the particulate pollution. Particulates may accelerate corrosion of metals and cause damage to paints and sculptures. They may absorb solar radiations and reduce visibility.

7. Heavy metals and other principal pollutants:

Some inportant pollutants including heavy metals are given in table no. 5.1. with their source and effects.

Table 5.1. Sources of some important air pollutants and their effect on human beings and animals

Pollutant	*Major Sources*	*Typical Effects*
Carbon monoxide (CO)	Incomplete combustion of fuels, automobile exhausts, jet engine emissions, blast fumaces, mines and tobacco smoking.	Toxicity, blood poisoning, increased proneness to accidents, CNS impairment. CO combines with haemoglobin, forming carboxy haemoglobin, which is useless for respiratory purposes and hence leads to death.
Sulphur dioxide (SO_2)	Combustion of coal, combustion of petroleum products, burning of refuse, petroleum industry, oil refining, power house, sulphuric acid plants, metallurgical operations and from domestic burning of fuels.	Increased breathing rate and feeling of air-starvation, suffocation, aggravation of ashma and chronic bronchitis, impairment of pulmonary functions, respiratory irritation, sensory irritation, irritation throat and eyes.
Oxides of Nitrogen (NO)	Automobile exhausts, coal-fired and gas-fired fumaces boilers, power stations, explosives industry, fertilizer industry, manufacture of HNO_3, combustion of wood and refuse.	Respiratory irritation, headache, bronchitis, pulmonary emphysema, impairment of lung defences, edema of lungs, lachrymatory effect, loss of appetite, corrosion of teeth.
Hydrogen sulphide (H_2S)	Coke ovens, kraft paper mills, petroleum industry, oil refining, viscose rayon manufacturing plants, manufacture of dyes, tanning industry and sewage treatment plants.	Headaches, conjunctivitis sleeplessness, pain in the eyes irritation of respiratory tract, respiratory paralysis, asphxiation malodorous. In high concentrations, it may lead to blockages of oxygen transfer, poisoning cell enzymes and damaging nerve tissues.
Chlorine (Cl_2)	Accidental breakage of chlorine cylinders, electrolysis of brine, bleaching of cotton pulp and other process industries using chlorine.	Irritation of eyes, nose and throat, toxicity, respiratory irritation, lachrymatory effects. In large doses it may cause edema, pneumonitis, emphysema and bronchitis.
Hydrogen fluoride (HF)	Glass fibre manufacture, chemical industry, fertilizer industry, aluminium industry, ceramic industry, phosphate rock processing.	Irritation, respiratory diseases, fluorosis of bones, mouling of teeth.
Carbon dioxide (CO_2)	Combustion of fuels, automobile exhausts, jet engine emissions.	Toxic in large quantities, Hypoxia.
Hydrocarbons	Organic chemical industries, petroleum refineries, automobile exhausts, rubber manufacture.	Some hydrocarbons have carcinogenic effects, lachrymatory effect
Oxidants (e.g.O_3)	Photochemical reactions in atmosphere involving organic materials and NO_2 etc. Reactions induced by silent electrical discharge and intense u.v. radiations in the atmosphere.	Irritation of lungs, eyes and respiratory tract. Accumulation of fluids in lungs and damage to lung capillaries. These biochemical effects of O_3 mostly arise from generation of free radicals which attack the-SH groups present in the enzymes.

Dusts	Asbestos factories, mining activities, power stations, metallurgical industries, ceramic industry, factory stacks, glass industry, cement industry, foundries.	Respiratory diseases, toxicity from metallic dusts, silicosis and asbestosis from the specific dusts. Asbestos dust cause pulmonary fibrosis, pleural calcification and lung cancer.
Ammonia (NH_3)	Chemical industries, coke oven refineries, stocks yards, fuel incineration.	Damage to respiratory tracts and eyes, corrosive to mucous membranes.
Formaldehyde (HCHO)	Waste incineration, automobile exhausts, combustion of fuels, photochemical reactions.	Irritation to eyes, skin and respiratory tract.
Hydrochloric acid (HCl)	By-product from chlorination of organic compounds, combustion of gasoline in which ethylene dichloride is present, burning of coal, paper and chlorinated plastics.	Inflammation and ulceration of upper respiratory tract, clouding of cornea, coughing and choking while inhalation.
Radioactive gases and dusts	Radioactive gases and suspended dusts from natural and artificial radioisotope sources.	Somatic effects such as leukaemia and other types of cancer, cataracts and reduction in life expectancy. Genetic effects such as mutations in human gametes.
Arsenic (As)	Arsenic containing fungicides, pesticides and herbicides, metal smelters, by-product of mining activities, chemical wastes.	Inhalation, ingestion or absorption through skin can cause mild bronchitis, nasal irritation or dermatitis. Carcinogenic activity also is suspected. Attack-SH groups of enzymes, coagulate proteins.
Beryllium(Be)	Coal, nuclear power and space industries, production of fluorescent lamps, motor fuels and other industrial use.	Damage to skin and mucous membranes, pulmonary damage, perhaps carcinogenic.
Boron (B)	Boron producing units, production and use of petroleum fuel and additives, burning coal and industrial wastes, detergent formulations.	Ingestion or inhalation as dust causes irritation and inflammation. Boron hydrides can damage CNS and may result in death.
Cadmium (Cd)	Cadmium producing industries, electroplating, welding. By-product from refining off Pb, Zn and Cu, fertilizer industry, pesticide manufacture, cadmium nickel batteries, nuclear fission plants, production of TEL used as additive in petrol.	Inhalation of fumes and vapours causes kidney damage, bronchitis, gastric and intestinal disorders, cancer, disorder of heart, liver and brain. Chronic and acute poisoning may result. Renal dysfunction, anaemia, hypertension, bone-marrow disorder and cancer.
Chromium (Cr)	Metallurgical and chemical industries, processes using chromate compounds, cement and asbestos units.	Toxic to body tissues, can cause irritation, dermatitis, ulceration of skin, perforation of nasal septum. Carcinogenic action suspected.
Lead (Pb)	Automobile emissions, lead smelters, burning of coal or oil, lead arsenate pesticides, smoking mining and plumbing.	Absorption through gastrointestinal and respiratory tract and deposition in mucous membranes, cause liver and kidney damage, gastro-intestinal damage, mental retardation in children, abnormalities in fertility and pregnancy.

Manganese (Mn)	Ferromanganese production, organo-manganese fuel additives, welding rods, incineration of manganese containing substances.	Poisoning of CNS, absorption, ingestion, inhalation, or skin contact may cause manganic pneumonia.
Nickel (Ni)	Metallurgical industries using nickel, combustion of fuels containing nickel additives, burning of coal and oil, electroplating units using nickel salts, incineration of nickel containing substances vanaspati manufacture.	Respiratory disorders, dermatitis, cancer of lungs and sinus.
Mercury (Hg)	Mining and refining of mercury, organic mercurials used in pesticides, laboratories using mercury.	Inhalation of mercury vapours may cause toxic effects and protoplasmic poisoning. Organo-mercurials are highly toxic and may cause irreversible damage to nervous system and brain.

Effects of Air Pollutants on Man and his Environment

(I) **Damage to materials.** The materials that may be affected by air pollutants include metals; building materials, rubbers, elastomers, paper, textiles, leather, dyes, glass, enamels and surface coatings. The types of possible damage to these materials by air pollutants include corrosion, abrasion, deposition, direct chemical attack and indirect chemical attack. The intensity of damage depends upon factors such as moisture, temperature, sunlight, air movement and of course the nature and concentration of the pollutants.

(2) **Damage to Vegetation.** Air pollutants, such as sulphur dioxide, HF, particulate fluorides, smog, oxidants like ozone, ethylene (from automobiles), NO_x, chlorine and herbicide and weedicide sprays exert toxic effects on vegetation. The damage usually manifests in the form of visual injury such as chlorotic marking, banding, silvering or bronzing of the underside of the leaf. Retardation of plant growth may also occur in some cases. The extent of damage to a plant depends upon the nature and concentration of the pollutant, time of exposure, soil and plant condition, stage of growth, relative humidity and the extent of sunlight.

(3) **Damage to farm animals.** Arsenic, lead and fluorides are the main pollutants which cause damage to livestock. These air-borne contaminants accumulate in vegetation and forage and poison the animals when they eat the contaminated vegetation.

Arsenic occurs as an impurity in coal and many ores. It is also used in insecticides. Livestock near smelting and other industrial operations suffer arsenic poisoning with symptoms like salivation, thirst, liver necrosis, inflammation of depression of central nervous system.

Lead is emitted from metallurgical smelters coke-ovens and coal combustion operations, lead arsenate sprays and automobile exhausts. Lead poisoning occurs in horses and other animals with symptoms such as depression, lethargy, gastritis, paralysis and breathing troubles.

Cattle and sheep are particularly susceptible to fluorine toxicity which may cause fluorosis of teeth and bones.

(4) **Darkening of sky and reduction in visibility**. Sky darkening may be caused by heavy smoke and fog or by dust storms. The reduction in visibility may be due to smoke, fog and industrial fumes which contain particulates in the size range of 0.4 to 0.9μ m that scatter light. The intensity of these effects depends upon the particle size, the angle of the sun, aerosol density, thickness of the affected air mass and meteorological factors such as inversion height, wind speed and humidity.

(5) **Effect on human health and human activities.** The effects of air pollution on humans, animals and vegetation has already been discussed in earlier sections. Air pollution can effect the

health of workers within the industrial premises, causing absenteeism, sickness and drop in production. Industrial hygiene measures are being taken by many industrial managements to combat these occupational disease. However, apart from the effects on industrial workers, air pollution also affects larger segments of general population. The notorious London smog of 1952, which lasted for 5 days causing 4000 deaths, is an example. Epidemiological and toxicological studies indicate a link between air pollution and respiratory conditions like chronic bronchitis, bronchial asthma, pulmonary emphysema and lung cancer. Irritation of nose, eyes and throat and bad odours due to air pollutants cause annoyance, allergy and health hazards.

Air pollution may cause sickness, absenteeism among workers and general lethargy, which naturally result in decrease in efficiency in all facets of human activity.

MEASURES TO CHECK AIR-POLLUTION

It is not easy to control/check air pollution at resonable cost, because it is not so simple. Our every life style/amentities of modern life is facing for air pollution. But we can check it or prevent by careful planning for industries, better design, operation of equipments and general awareness to do this. The following are the general methods of air pollution control :

1. Controlling the air pollution at source.
2. Site selection/Zoning
3. Controlling air pollution by devices/equipments/process modification.
4. Air pollution control by growing vegetation.
5. Air pollution control by Fuel selection and utilization.

1. Controlling of Air Pollution at Source

This is the best to check air pollution at source. This can be achieved by :

(i) Modifying the process in such a way that pollutants do not form at all beyond the permissible limits.

(ii) Before release the pollutants, they should be reduced to telerable levels by methods equipments to destroy, alter, trap or so.

To control or minimised air pollution at source, the following steps should be strictly follow :

(a) This step can also be done in two ways, Ist we should select the raw material in such a way to release minimum pollutants. The supplements may also be used if needed. Secondly use suitable fuels avoiding sulphur fuels. Non-essential ingredients are removed before processing of the raw material.

(b) Air pollution can easily be checked by using modified procedure or new process. Timely it should be monitored.

(c) Equipment alternations such as the use of vented tanks should be avoid. Use floating root tanks. For industry, new furnaces, modified equipments should be used.

(d) By using modified equipment, the pollutants are stored at one place, form where they should removed timely.

2. Site Selection/Zoning

To instal the industry, site selection is important, which results in the production of single source of pollution. Control measure based on the knowledge of the mechanics of the atmosphere is called "Zoning". While setting the factories the meterological and micro-meterological conditions

should be considered. Other factors such as facilities for as material supply, transport labour and market for products are also important for selecting the site of industry.

For improvement of the people's health. Zoning should be done properly. The industries running on electrical power and causing, no nuisence may be sitted near residential area. But opposite to this, they may be located far away from residential area.

3. Controlling of Air Pollution by Devices/Equipments/Process Modifications

Large number of factories/industries release various types of gases, along with particulates which are measure source of air pollution. In order to prevent these pollutants two types of methods are used.

(A) Methods/Equipments used to Control gaseous Pollutants

For gaseous pollutants, following methods are generally used :

(i) Absorption (ii) Adsorption

(iii) Combustion (iv) Cold trapping or condensers

(v) Others.

But the first three are in common use.

(i) Absorption : Scrubbers are mostly used for the removal of gaseous pollutants. They have suitable liquid as absorbent to remove or modify one or more of the pollutants present in the stream. Through scrubbers gaseous effluents are passed. The efficiency of gas absorption depend upon the following factors :

(a) Chemical Activity of the gas pollutant. (b) The extent of the surface for contact.

(c) The contact time. (d) The concentration of the absobing medium.

This technique is used for removal of NOx, H_2S, SO_2, SO_3 fluorides etc.

(ii) Adsorption : Here, the gaseous effluents are passed through porous solid adsorbent taken in suitable containers. The efficiency of adsorption depends upon the surface area per unit weight of the absorbent. Constituents of the gas effluents are held at the interface of the adsorbent by chemisorption. When the effluents have higher concentration of Nox, Sox etc. the gases can be recovered economically and used for the manufacture of acids, *i.e.*, HNO_3 & H_2SO_4 etc.

Some important adsorbent/adsorbent are given in table :

Table : Absorbents and Adsorbents for Some Gaseous Pollutants

Pollutants	Absorbent	Adsorbent
Nox	H_2O & aq. HNO_3	Silica gel, commercial zeolites
HF	H_2O & NaOH	Porous pellets of NaF, limestone.
H_2S	Ethanol amines, $NaOH^+$ Phenol, Sodium Alanine, Soda Ash, Sodium thioarsenate, Tripotassium Phosphate.	Iron-Oxide
SO_2	Water, Alkaline H_2O, Sulphites of Ba, Ca or Na, Dimenthyl aniline, Aluminium Sulphate.	Dolomite, Alkaline alumina

The Sox can be removed from the boiler/furnaces by injecting CaO (Pulverised lime stone). Thus the emission of SOx is prevented, because CaO formed $CaSO_3$ & $CaSO_4$ with SOx.

(iii) Combustion : The flame combustion or catalytic combustion of organic gaseous pollutants convert them in to H_2O & CO_2. Flame combustion include fume incinerators, steam injection while catalytic combustion is resorted where lower temperature is needed.

(B) Methods/Equipments used to Control Particulate Emission

The particulate collection devices are based on the size, shape, properties of the particulate, which are generally originate from stationary and mobile sources. The various methods are :

(i) Filtration
(ii) Mechanical
(iii) Precipitators
(iv) Scrubbers.

(i) Filtration : Different type of filters are generally used, *i.e.*, Fibrous, deep bed, cloth bag filters. The particulate matter is passed through filters, particles are trapped & collected in filters. Cloth & Nylon filters are used up to 80-90°C while silicone & asbestos covered glass, cloth filters can be used up to 250-350°C. After filtration gas devoid of the particles are discharged out.

(ii) Mechanical : It includes the two mechanisms :

(a) Gravity settling in which the velocity of the horizontal carrier gas is reduced so that particles settle by gravitational force.

(b) Sudden change of direction of the gas flow causes the particles to separate.

Gravity settling chambers consists of a chamber in which dust is separated from the gas but reducing the velocity of the gas. As a result dust particles settle down in the chamber, coarse particles are thus removed. These chambers are capable of removing only the large particles of size, 25-30 μm diameter.

(iii) Precipitators : These are generally electrostatic in nature hence called electrostatic precipitators. Particles with diameter as small as 0.0001 cm. can be removed by passing the stack gas through electrostatic precipitator.

It works on the principle that when particulates move through a region of high electric potential, they become charged and then they are attracted to an oppositely charged area, where they are collected and removed. It consists of a series of plates which are charged to high voltage alternatively + and –. Particles approaching given plate tend of aquire its charge. They are then attracted to the surface of the next plate, from which they fall into the hopper below. Thus particles pick up charge as they pass between the plates and are precipitated on plates of opposite charge. The potential across the plates is around 50,000 V. The high voltage in the wires produces billions of electrons and bombard the gas molecules, which become positively and negatively charged. The positive ions return to the negative end electrode and gain electrons while the negative ions combines with the dust particles and make them negatively charged. The negatively charged dust particle collect as the positively charged plates. Electrical attraction becomes weak when dust layer becomes 6 mm thick.

(iv) Scrubbers : In this device the particles are wash out of the gas flow by a water spray. The object is to transfer suspended particulate matter in the gas to the scrubbing liquid which can be readily removed by the gas cleaning device. This leaves the gas clean to pass onwards to the process for which it is being used or alternatively to be discharged to the atmosphere. The most common scrubbers are :

(i) Cyclonic scrubbers

(ii) Venturi scrubbers

In cyclonic scrubbers the aerosol is introduced in a centrifugal manner. Water is sprayed at the entrance of gas and plates are provided to remove the moisture from the gas after the removal of the dust. This is followed by a control equipment such as gravity settling chamber or cyclones. Cyclonic scrubbers have an efficiency of 90% and it can remove dust particles of 5 μm size. It is capable of cleaning about 2000 litres of gas per minute.

In venturi scrubber consists of venture throat though which dirty gas is passed at a rate of about 3400-12600 mm per minute. Water added in the direction of low so that the water enters at the throat. Efficiency, of this is also 99% and is capable of cleaning even very fine particles. It can clean 4000 litres of gas per minute.

(4) Controlling of Air Pollution by Growing Vegetation

Planting of trees is very helpful in reducing air pollution due to dry flyash and coal dust. Trees should be planted all around the source in order to reduce the spreading of air pollution from pollutants coming out from industry/source. Cultivation of pollution resistant species is the best possibility of reducing air pollution. The odours of gases can be absorbed by passing them through beds of activated charcoal of sand or soil. The odours can also be controlled by the oxidation of the compounds using chlorine, ozone & Hydrogen peroxide as oxidising agent.

WATER POLLUTION

INTRODUCTION

Water is essential for the survival of any form of life. On an average, a human being consumes about 2 litres of water everyday. Water accounts for about 70% of the weight of a human body. About 80% of the earth's surface (i.e., 80% of the total 50,000 million hectares in area) is covered by water. Out of the estimated 1,011 million km^3 of the total water present on earth, only 33,400 m^3 of water is available for drinking, agriculture, domestic and industrial consumption. The rest of the water is locked up in oceans as salt water, polar ice-caps and glaciers and underground. Owing to increasing industrialization on one hand and exploding population on the other, the demands of water supply have been increasing tremendously. Moreover, considerable part of this limited quantity of water is polluted by sewage, industrial wastes and a wide array of synthetic chemicals. The menace of water-borne diseases and epidemics still threatens the well-being of population, particularly in under-developed and developing countries. Thus, the quality as well as the quantity of clean water supply is of vital significance for the welfare of mankind. An analysis conducted in 1982 revealed that about 70% of all the available water in our Country is polluted.

Municipal water is mainly used for drinking purposes and for cleaning washing and other domestic purposes. The water that is fit for drinking purposes is called potable water.

Characteristics of Potable Water

1. It should be colourless, odourless and tasteless.
2. It should be free from turbidity and other suspended impurities.
3. It should be free from germs, bacteria and other pathogenic organisms.
4. It should not contain toxic dissolved impurities, such as heavy metals, pesticides, etc.
5. It should have a pH in the range 7-8.5.

6. It should be moderately soft, having hardness preferably in the range 50-100 PPm. Its hardness should not be above 150 PPm.
7. It should be aesthetically pleasant.
8. It should not be corrosive to the pipelines and should not cause any incrustations in the pipes.
9. It should not stain clothes.

Table 5.1. Standards (maximum permissible limits) for drinking water as recommended by World Health Organisation (WHO).

Parameters	*Level WHO standard*
pH	6.5-9.2
BOD	6
COD	10
Arsenic	0.05 PPm
Calcium	100 PPm
Cadmium	0.01 PPm
Chromium	0.05 PPm
Ammonia	0.5 PPm
Copper	1.5 PPm
Iron	1.0 PPm
Lead	0.1 PPm
Mercury	0.001 PPm
Magnesium	150 PPm
Manganese	0.5 PPm
Chloride	250 PPm
Cyanide	0.05 PPm
Nitrate + Nitrite	45 PPm
Polyaromatic hydrocarbons (PAH)	0.2 PPm
Selenium	0.01 PPm

Water Pollutants and their Sources

The various types of water pollutants are:-

(a) **Oxygen-demanding wastes.** These include domestic and animal sewage, bio-degradable organic compounds and industrial wastes from food-processing plants, meat-packing plants, slaughter-houses, paper and pulp mills, tanneries etc., as well as agricultural run-off. All these wastes undergo degradation and decomposition by bacterial activity in presence of dissolved oxygen (D.O.). This results in rapid depletion of D.O. from the water, which is harmful to aquatic organisms. The optimum D.O. in natural waters is 4-6 ppm, which is essential for supporting aquatic life. Any decrease in this D.O. value is an index of pollution.

(b) **Disease-causing wastes.** These include pathogenic microorganisms which may enter the water along with sewage and other wastes and may cause tremendous damage to public health. These microbes, comprising mainly of viruses and bacteria, can cause dangerous water-borne diseases such as cholera, typhoid, dysentry, polio and infectious hepatitis in humans. Hence, disinfection is the primary step in water pollution control.

(c) **Synthetic Organic Compounds.** These are the man-made materials such as synthetic pesticides, synthetic detergents (syndets), food additives, pharmaceuticals, insecticides, paints,

synthetic fibres, elastomers, solvents, plasticizers, plastics and other industrial chemicals. These chemicals may enter the hydrosphere either by spillage during transport and use or by intentional or accidental release of wastes from their manufacturing establishments. Most of these chemicals are potentially toxic to plants, animals and humans.

(d) **Sewage and agricultural run-off.** Sewage and run-off from agricultural lands supply plant nutrients, which may stimulate the growth of algae and other aquatic weeds in the receiving water body. This unwieldy plant-growth results in the degradation of the value of the water body, intended for recreational and other uses.

(e) **Oil.** Oil pollution may take place because of oil spills from cargo oil tankers on the seas, losses during off-shore exploration and production of oil, accidental fires in ships and oil tankers, accidental or intentional oil slicks (as in the Gulf War between Iraq and U.S.-led allied forces in the year 1991) and leakage from oil pipe-lines, crossing waterways and reservoirs. Oil pollution results in reduction of light transmission through surface waters, thereby reducing photo-synthesis by marine plants. Oil pollution in Seas has been increasing due to the increase in oil based technologies, massive oil shipments, accidental oil spillages etc.

(2) Inorganic Pollutants

Inorganic pollutants comprise of mineral acids, inorganic salts, finely divided metals or metal compounds, trace elements, cyanides, sulphates, nitrates, organometallic compounds and complexes of metals with organics present in natural waters. The metal-organic interactions involve natural organic species, such as fulvic acids and synthetic organic species, such as EDTA. The heavy metals such as Hg, Cd and Lead, metalloids such as As, Sb and Se are most toxic. The water pollution by heavy metals occurs mostly due to street dust, domestic sewage and industrial effluents. Polyphosphates from detergents are also water pollutants.

(3) Suspended solids and sediments

Sediments are mostly contributed by soil erosion by natural processes, agricultural development, strip mining and construction activities. Suspended solids in water mainly comprise of silt, sand and minerals eroded from the land. Soil erosion by water, wind and other natural forces are very significant for tropical countries like India. It is estimated that 5.37 million Tonnes of NPK fertilizers are washed away in to the sea. Sediments and suspended particles exchange cations with the surrounding aquatic medium and act as repositories for trace metals such as, Cu, CO, Ni, Mn, Cr, and Mo.

(4) Radioactive Materials

The radioactive water pollutants may originate from the following anthropogenic activities:

(a) Mining and processing of ores, e.g., Uranium tailings.

(b) Increasing use of radioactive isotopes in research, agricultural, industrial and medical (diagnostic as well as therapeutic) applications, e.g., I^{131}, P^{32}, Co^{60}, Ca^{45},S^{35},C^{14}, Rb^{86}, Ir^{132} and Cs^{137}

(c) Radioactive materials from nuclear power plants and nuclear reactors, e.g., Sr^{90}, Cs^{137}, Pu^{248}, Am^{241}.

(d) Radioactive materials from testing and use of nuclear weaponry, e.g., Sr^{90}, Cs^{137}

The radioactive isotopes found in water include Sr^{90}, I^{131}, Cs^{137},Cs^{141}.Co^{60}, Mn^{54}, Fe^{55}, Pu^{239}, Ba^{140}, K^{40}, Ra^{226}.

(5) **HEAT.** Considerable thermal pollution results from thermal power plants, particularly the nuclear-power-based electricity generating plants. In such industries, where the water is used as a coolant, the waste hot water is returned to the original water bodies. Hence the temperature of the water body increases. This rise in temperature decreases the DO content of water, which adversely affects the aquatic life.

EFFECTS

Some important effects of various types of water pollutants are as:-

(i) Tannery effluents contain several constituents which are deleterious, irrespective of the fact that where they are discharged viz., into river, stream, sewer, land or sea.

(ii) It imparts persistent dull brown colour to the receiving water causing aesthetic and other problems described earlier.

(iii) Highly repulsive odour is imparted to the receiving water. The dissolved constituents like proteins are purifiable.

(iv) The acidic or alkaline effluents are corrosive to concrete and metal pipes.

(v) Excess NaCl in the effluent is also corrosive and renders the receiving water unsuitable for irrigation.

(vi) The effluents may contain pathogenic bacteria.

(vii) The dissolved chromium present is toxic to fish and aquatic life and thus affects the natural self-purification property of the stream.

(viii) The suspended solids such as hair, flesh, $CaCO_3$' etc. interfere with aeration and photosynthetic activities of the aquatic flora.

(ix) If the wastewater is discharged into sewer, the suspended impurities such as $CaCO_3$, hairs etc. may choke the sewerage pipes. The sulphides present in the wastewater cause "crown corrosion" to the concrete structures, etc.

(x) The chromium and sulfides present in the waste water being toxic to microorganisms disrupt the biological treatment operation such as trickling filtration. The suspended lime etc. also interfere with the biological activities in the sewage treatment plants.

(xi) The presence of excessive salt and Cr in the wastewaters may deteriorate the quality of the ground water in the affected areas.

(xii) High amounts of fluoride (over 1000 mg/1) present in phosphatic fertilizer effluent enrich the fluoride content of the receiving waters causing dental and skeletal fluorosis to humans, abnormal calcification of bones in animals and adverse effects on plants. Presence of Cr, cyanide, ammonia are harmful to aquatic life.

(xiii) Volatile substances such as alcohols, aldehydes, ethers and gasoline may cause explosion in sewers.

(xiv) Suspended solids such as silt and coal may injure the gills of the fish and cause asphyxiation.

(xv) Suspended solids may also cause bad odour and tastes and also may promote conditions favourable for growth of pathogenic bacteria.

(xvi) Radioactive isotopes are toxic to life-forms. For instance, Sr^{90}, which emanates from testing of nuclear weapons, accumulates in bones and teeth and causes serious disorders in human beings. The maximum permissible level of Sr^{90} in water is 10 pico curies per liter (1 pico curie = 10^{12} curie).]

CONTROL OF WATER POLLUTION

The control of water pollution is difficult, but we may try for its prevention and minimisations. Industrialised and Developing countries spend a handsome amount of their GNP (Gross National Product) on pollution control measures, but the problem is going to be worsening day by day. The main worries before water pollution control are:-

1. How pure the water should be? 2. How to prohibit the effluents and discharge in to water? 3. To what extent water quality be improved? 4. How to create public opinion against

water pollution? Therefore, we should adopt the respective safety measures to achieve acceptable water quality at the least cost. Some of these are :-

1. Scientific techniques are necessary to be adopted for the environmental control of catchment areas of rivers, lakes, ponds or streams.
2. Industrial plants should be based on recycling operations.
3. The possible reuse or recycle of treated sewage effluents and industrial wastes should be emphasized and encouraged.
4. Instead of throwing wastes in to water, the recycling should be done for better use. Gobar gas plant, composting, manufacture of hardboard, paper etc. such examples where respective waste can be used.
5. Minimum, appropriate quantity and concentration of Fertilizers, pesticide & insecticides should be used, because excess will cause pollution.
6. There should be propaganda for water pollution control, on radio, TV, Newspapers etc. because public awareness is a must.
7. Treatment plants should be constructed and Govt should also help by funding for domestic, sewage and industrial effluents.
8. Local authorities, Industrialists, Govt officials, with public participation should co-ordinate to finds ways to control water pollution.
9. Water resources should be used in the best possible economic way.
10. To conduct seminars and training courses for helping those, who are directly or indirectly engaged in water management and water pollution control.
11. Govt. should encourage people to participate in research programmes like disposal of sewage and industrial effluents.
12. Destruction of forest should be discouraged our goal should be –"Conservation of forests" and "Plant more trees".
13. Techniques like adsorption, electro dialysis, ion exchange and reverse osmosis etc can be used for the removal of water pollutants.
14. Plants should be developed to recover metal from metal bearing waste water.

SOIL POLLUTION

INTRODUCTION

Soil is a very important constituents of the lithosphere. The word "Soil" is derived from a Latin word "Solum" which means earthy material in which growth of plants takes place. "Soil" may be broadly defined as the weathered layer of the earth's crust with living organisms and their products of decay. It is a complex physio-biological system containing water, mineral salts, nutrients and dissolved oxygen. It provides anchorage to plants. The study of Soil science is called pedology or edaphology.

Earth's crust comprises of rocks and the loose material derived from these rocks, the disintegration of which results into the formation of gravel, sand, silt and clay. About 99% by weight of earth's crust is constituted by about 12 elements only, whereas the other elements exist in traces. The basic composition of the earth's crust is shown in table (5.2).

Table 5.2: Elementary composition of the earth's crust.

Elements present	*Percentage by weight*
Oxygen	49.85
Silicon	26.03
Aluminium	7.28

Iron	4.12
Calcium	3.18
Sodium	2.33
Potassium	2.33
Magnesium	2.11
Hydrogen	0.97
Titanium	0.41
Chlorine	0.20
Carbon	0.19
Others	1.00

The earth's crust basically consists of the following three rock types.

1. **Igneous rocks** : These are formed by cooling and solidification of molten rock material called 'Magma'. Ex:- Basalt and Diorite.

2. **Sedimentary rocks** : These are developed as a result of gradual accumulation, consolidation and hardening of products of weathering of mineral materials brought about by wind or waters. These rocks are characterized by the presence of distinct sedimentary layers. Ex :- Lime stone, sand stone and shale.

3. **Metamorphic rocks** : These are formed as result of metamorphosis of igneous and sedimentary rocks under the influence of high pressure and intense heat. Ex:-Quartzite, Slate, Marble and Schist.

Out of about 2000 minerals known, nearly 99% of the earth surface is made of only about 10 to 12 minerals. The following four mineral groups account for over 90% mass of terrestrial rocks.

Feldspars	58%
Pyroxenes	16%
Quartz	13%
Mica	4%

The common minerals found in the earth crust are shown in Table (5.3).

Table 5.3 : Common minerals found in earth crust and their composition.

Name of the mineral	Chemical composition
Feldspars	$K_2Al_2Si_6O_{18}$, $NaAlSi_3O_6$, $CaAl_2Si_3O_8$
Pyroxenes	(Mg, Fe) SiO_3
Quartz	SiO_2
Micas	$KAl_2(AlSi_3O).(OH)_2$
K Mg Fe-Al Silicates	
Olivine and serpentine	$(Mg.Fe).SiO_4$
Amphiboles	$(Mg.Fe).(Si_4O_{10}.(OH)_2$
Calcite	$CaCO_3$
Magnetite	$MgCO_3$
Dolomite	$CaCO_3.MgCO_3$
Oxides of Iron	
(Haemetite, Magnetite, Limnite)	Fe_2O_3, Fe_3O_4, $FeO(OH).XH_2O$
Montmorillonite	$(Ca\ MgO).Al_2O.5SiO_2.5H_2O$
Kaoline	$Al_2O_3.2SiO_2.2H_2O$

Importance of Soil to the Biosphere

Soil plays a vital role in determining the quality and composition of the biosphere which develops over it. The multiferious functions of soil are as follows:

(i) Soil provides mechanical support to the plants.

(ii) Owing to the porosity and water-holding capacity of soil, it serves as a reservoir of water and supplies water to the plants through their roots even when the land surface is dry.

(iii) The ion-exchange capacity of the soil ensures availability and supply of micro-and macro-nutrients for the growth of plants, animals and microbes. It also helps in preventing excessive leaching of nutrient ions, while maintaining proper pH.

(iv) The colloidal components of soils which comprises of clay micelles and humus particles (less than 0.002mm) tightly adsorb a number of nutrient ions and supply them evenly to the plants.

(v) Soil contains organotrophic bacteria, nitrifying bacteria, nitrogen-fixing bacteria. Fungi, protozoans and other microbes which help in decomposition and mineralization of organic matter and regeneration of nutrients.

Major types of soil in India

The major types of soil occurring in different parts of our country are given in Table (5.4). below:

Table 5.4 : Major types of Soil in Our Country.

Type of Soil		Remarks
1. Alluvial Soil	-	Occur in the great-northern plains of India and deltas of rivers in peninsular India.
(a) Khadar	-	Very fine and new alluviam. Very fertile.
(b) Bangar	-	Relatively coarse and old alluviam. Relatively less fertile.
2. Mountain or hill soils and forest soils	-	Rich in organic matter (humes), occur in eastern and western ghats hills in Central India and northern hilly regions of Himalyas.
3. Black soils	-	Originate from volcanic rocks. Highly fertile clay soils. Occur in parts of M.P. Tamilnadu, Gujarat and Deccan trap regions of Maharashtra.
4. Red soils	-	Relatively less fertile. Deficient in organic and nitrogenous matter. Occur in plateaus of Kerala, Karnataka, A.P., Tamilnadu, Orissa and Southern parts of Bihar.
5. Lateritic soils	-	These are poorly fertile but can support pastures and scrub forests. These soils occur in regions of tropical rainy climate such as western ghats, chota Nagpur plateau, assam, Orissa, A.P., Tamilnadu and Kerala.
6. Desert soils	-	These are arid sandy soils with low moisture and low humus content. They occur mostly in Rann of Catch, Southern Punjab, Western Rajasthan and Haryana.

Plants as pollution indicators

Some plant species have been used as indicators of pollution of soil, air and water. Certain plant species such as chara utricularia and Wolffa were found to grow well in polluted water. Species like agrotis, festuca, anthoxanthum and impatiens are used as metallic tolerance plant indicators for Cu, Pb, Zn and Cd respectively. Presence of diatoms indicate sewage pollution.

Escherichia coli bacteria indicate water pollution. Leaf cabbage indicate accumulation of polycyclic hydrocarbons in the soil. The growth of lichens was found to decrease when the soil is polluted. Soil pollution inhibits plant growth and reduce productivity. Plant growth is inhibited or destroyed in areas near smelters.

Sources of Soil Pollution

Soil pollution differs from water pollution or air pollution, because the pollutants remain in direct contact with the soil for relatively longer periods and hence alter the chemical and biological properties of the soil. The hazardous chemical can also enter the human food chain from soil or water plants.

The major sources of metallic contamination of soils include mining, smelting, sludge, fertilizers, pesticides, composted town refuse etc. Metals such as Cd, Pb, Hg, Ni, Mo, Ni, Cr etc. are toxic to plant and animal life.

Indiscriminate dumping of industrial wastes and municipal wastes leads to the leaching and/or seepage of toxic substances into the soil and pollution of ground water. Further due to some modern agricultural practices, obnoxious pesticides, fungicides, insecticides, biocides, bacteriocides, etc. contaminate land. Direct pollution of soil by dangerious pathogenic organisms is also important.

Fly ash generated from thermal power plants, industrial waste discharged into streams or dumped into the surrounding land, mining wastes, non-biodegradable organic pollutants, industrial sludges such as flue gas desulphurization sludge, heavy metal sludge sets, cause serious water and soil pollution problems.

Commercial and domestic urban wastes consisting of cried sewage sludge as well as garbage and rubbish materials such as plastics metal cans, glasses, street sweepings, waste paper, fibres, rubber etc contribute to soil pollution.

Human and animal excretia, farm wastes, soil conditioners, soil fumigants, radioactive wastes, etc, also cause soil pollution.

EFFECTS OF SOIL POLLUTANTS

"*Soil Pollution*" was originally defined as the contamination of the soil system by considerable quantities of chemical or other substances, resulting in the reduction of its fertility or productivity with respect to the qualitative and quantitative yield of the crops. However, if some of the contaminants are such that if they are taken up by the plants (with or without any detrimental effects on them), and enter into the food chain and impart detrimental or toxic effect on the consumers, then that also should be treated as soil pollution.

Soil pollution is receiving greater and greater attention due to its direct impact on public health. The major effects of various types of pollutants are given below:

(a) Effects of modern agricultural practices:

Synthetic Fertilizers **:** Synthetic fertilizers are employed to increase the soil fertility and crop productivity. These fertilizers concentrate the essential nutrients in layer of top soil. However, the soil enriched by chemical fertilizers cannot support the microbial flora which are so essential to enrich the humus that helps in plant growth. Excessive and indiscriminate use of chemical fertilizers may result in the following undesirable effects:

(i) Wheat, maize, corn, etc. grown on soils fertilized with NPK fertilizers may result in considerable reduction in protein content of the crop.

(ii) Excessive use of nitrogenous fertilizers leads to the accumulation of nitrates in the soil which may contaminate the ground water. Nitrate concentrations exceeding 90 ppm in drinking water may lead to diarrhoea, blue Jaundice (Cyanosis) in children, "methemoglobinemia" (or blue baby syndrome) in infants. Further, the nitrates and nitrites

entering the human body may be eventually converted nitroso amines and other nitroso-compounds which are suspected to cause stomach cancer. Surveys in Rajasthan and other parts of the country indicated much higher nitrate levels than the permissible 45 ppm levels.

(iii) Vegetation growth in nitrate-rich soils may exert toxic effects in cattle.

(iv) Excessive use of chemical fertilizers may enter the water bodies and contribute to "eutrophication". (Eutrophication is the excessive growth of algae and aquatic plants to undesirable levels).

(v) Excessive use of chemical fertilizers may reduce the ability of plants to fix nitrogen.

(vi) Excessive quantities of potassium fertilizers in soils may reduce the quantities of valuable ascorbic acid (vitamin C) and carotene in fruits and vegetables grown in such soils.

(vii) The large-sized fruits and vegetables grown in highly fertilized soils may be more vulnerable to attacks by pests and insects.

Pesticides

As per the reports of the World Health Organization (WHO), about 50,000 people in developing countries are poisoned and about (5,000) people die because of improper use of pesticides and other chemicals in modern agricultural practices.

Pesticides pose potential hazard to animals, humans and aquatic life. They also cause deleterious effect on soil fertility and crop productivity. Pesticides applied to crops are retained in the soil in considerable quantities. They enter into cyclic environmental processes such as absorption by soil, leaching by water, etc, and contaminate both lithosphere and biosphere. Pesticides including herbicides, fungicides and rodenticides, are persistant pollutants. Owing to interactions between lithosphere and biosphere, pesticides may enter the food chain and pose serious health hazards. Some of them undergo metabolic transformation and bio-degradation. The degradation products of some of the pesticides are more dangerous than their respective parent compounds. Some of the pesticides residues are carcinogenic while their metabolic products too are toxic. The rate of degradation of pesticides depend upon their properties and structural characteristics.

The following types of pesticides are commonly used:

(a) Chlorinated hydrocarbons (eg. DDT, Aldrin, Dieldrin, Lindane, BHC etc.)

(b) Carbamate compounds (eg. Carboryl or Sevin, Zectrion etc.)

(c) Organo-Phosphorous compounds (eg. Methyl or ethyl parathion, melathion, guthion etc.)

(d) Inorganic compounds (eg. As_2O_3, PbO_2, $NiCl_2$, $CuSO_4$ etc)

(e) Miscellaneous compounds (eg, Organic mercurials, 2.4D; 2.4,5T etc)

Some of the adverse effects of pesticides are given below:

(i) Some arsenic pesticides may render the soil permanently infertile.

(ii) Pesticide residues in soil may be taken up by plants and cause phyto-toxicity. They may enter the aquatic environment and enter the food chain.

(iii) Pesticides such as, endrin, dieldrin, DDT, hepachlor etc. may seep through the soil and contaminate groundwater and surface waters. They may eventually contaminate drinking water supplies.

(iv) Fruit, vegetables, rice, wheat, barley, maize etc. are known to contain considerable quantities of toxic pesticide residue such as of DDT, BHC and other organochloro pesticides.

(v) Polychlorinated biphenyls (PCB) having half-life periods of about 25 years in soil are among the most hazardous soil pollutants. They may accumulate in soil and plants and when they eventually enter the animal or human body, they may cause severe health disorders including eye damage, skin problems, nervous disorders, foetus deformities and liver or stomach cancer.

(vi) Irrigated water from pesticide contaminated soils may evaporate and spread the toxic pesticide vapours in the atmosphere.

(vii) DDT can enter the food chain and accumulate in human fats and may lead to disorders such as impotency.

(viii) Persistant pesticides can damage human tissues and interfere with the normal metabolic activities by disturbing enzymatic functioning.

(ix) Chlorinated pesticides and herbicides are hazardous soil pollutants which can affect the soil texture and damage the ecosystem.

(x) Herbicides such as dioxan may cause congential birth defects in offsprings.

(xi) Hunting birds feeding on grains contaminated with DDT are threatened of extinction.

(xii) Organophosphate pesticides may cause muscular disabilities, tremors and dizziness.

(xiii) Excessive use of synthetic pesticides may lead to defoliation of forests and adverse effect on fauna and flora.

(xiv) Farm animals drinking stagnant water in fields sprayed by pesticides developed toxic symptoms and some mortalities were reported.

(xv) Farmers and farm workers are particularly prone to pesticide poisoning because of greater exposure while handling and spraying.

(xvi) Accidental spillages and leakages in pesticide manufacturing industries cause disastrous effects on the people residing in nearby areas due to pollution of air, water and soil. The Bhopal tragedy on 3rd December, 1994 is a lingering example.

(xvii) Contaminated soils may act as potential carriers of pathogenic bacteria and other dangerous organisms which may endanger human health.

(xviii) Volatile pesticides may cause pollution of air in the surrounding areas.

(b) Effects of Industrial Effluents:

Solid, liquid and gaseous chemicals from various industries as such paper and pulp, iron and steel, fertilizers, dyes, automobiles, pesticides, tanneries, coal-based thermal power plants etc. contain a variety of pollutants such as toxic heavy metals, solvents, detergents,plastics, suspended particulates and refractory/non-bio-degradable/recalcitrant chemicals. If they are not properly treated at source, they give rise to water, air-and soil pollution. Fly ash resulting from coal-based thermal power plants is one of the alarming and continuously increasing source of soil-pollution leading to degradation of soil, apart from water-and air-pollution in the nearby areas. Some trade wastes such as tannery wastes may contain pathogenic bacteria.

Indiscriminate dumping of untreated or inadequately treated domestic, mining and industrial wastes on land is an important source of soil pollution.

Fall-out of gaseous and particulate air-pollutants from mining and smelting operations, smoke-stacks, etc. is a major source of soil pollution in nearby areas.

(c) Effects of urban wastes:

Millions tones of urban waste are produced every year from critically polluted cities. The inadequately treated or untreated sewage sludge not only pose serious health hazards but also pollute soil and decrease its fertility and productivity. Other waste materials such as rubbish, used plastic bags, garbage, sludge, dead animals, waste medicines, hospital wastes, skins, tyres, shoes, cans, etc. also cause land and soil pollution. Some solid wastes may cause clogging of ground water filters. Suspended matter present in sewage can act as a blanket on the soil and interfere with its productivity.

Apart from the above major sources, radioactive waste dumped in the soil from natural and man-made sources, soil erosion due to deforestation, unplanned irrigation and unscientific agricultural practices are also result in land and soil pollution.

Control of Soil Pollution

As discussed in earlier sections, the major sources of soil pollution are the domestic wastes, industrial wastes and agricultural wastes including those toxic chemicals (eg. Pesticides) arising from modern agricultural practices. The various approaches to control soil pollution are as follows :

(1) Implementing stringent and pro-active population control programmes.

(2) Launching extensive afforestation and community forestry programmes.

(3) Implementing deterrent measures against deforestation.

(4) Formulation of stringent pollution control legislation and effective implementation with powerful administrative machinery.

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

(6) Banning the use of highly toxic and resistant synthetic chemical pesticides or atleast regulating/restricting their use only for special purposes under thorough monitoring.

(7) Encouraging the use of bio-pesticides in place of toxic chemical pesticides.

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

(9) Transforming intensive agriculture into a sustainable system by measures such as

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

(b) Infusing bio-diversity in agriculture by sowing mixed crops, crop rotation etc.

(10) Effective treatment of domestic sewage by suitable biological and chemical methods and adopting modern methods of sludge disposal.

(11) Municipal wastes have to be properly collected by segregation treated and disposed scientifically in land fills. Recycling and re-use of materials should be done wherever possible, such as recycling of glass, plastics, paper and production of bio-gas.

(12) Industrial wastes have to be properly treated at source, by segregation of wastes and/or adopting integrated waste treatment methods. Proper care should be taken in treating heavy metal wastes and other obnoxious waste materials.

(13) Security land-fills have to be constructed for permanent disposal of hazardous and recalcitrant industrial wastes.

(14) Sponsoring more intensive R & D efforts on bio-fertilizers, bio-pesticides utilization of wastes by recovery, reuse and recycling processes, and safer treatment and disposal of hazardous waste.

(15) Enforcing environmental audit for industries and promoting ecolabelled products.

(16) Avoiding excessive use of chemical fertilizers and insecticides and providing more organic manures to the fields and thereby maintaining healthy biota. This in turn regenerates soil fertility. A soil rich in organic mater also helps in controlling soil erosion.

MARINE POLLUTION

INTRODUCTION

Seas are the unlimited source of water for man. Secondly they are the main source of food and earnings for persons living in coastal areas. When the marine water is polluted it effects the

animals and other food chain components. Researches shows that many marine animals secrets the medicinal chemicals which are useful to mankind and other living organisms. When water will be polluted it will effect the animals present in seas. Generally drainage from rivers, industries, human activities from coastline area, disposal of radioactive wastes and toxic materials, leakages from ships are main source of marine pollution. When ships and other animals take such polluted water get affected. When man take them dies. Leaked oil other pollutants from ship spread over in sea, get absorbed on sediments. It effects the marine life. This is due to dumping of wastes material from outside, which is harmful too, in ocean affect their ecosystem. This is known as marine pollution.

Sources of marine Pollution

The main sources of marine pollution are:-

1. Rivers are the main source of marine pollution. They carry wastes in their drainage and joins the sea/ocean. The drainage include sewage sludge, industrial effluents, detergents, agrochemicals, plastics, metal scraps etc.
2. Catchment area-like India and other countries too, many big cities and industries are situated along the coast line. Every large amount of wastes from hotels, wastes effluents mixed with detergents, sewage from corporations and industries, other wastes from human activities are mixed in sea water.
3. Ships which carry toxic substances, lubricating oil, paints heavy oils, fuels, automotive materials and other chemicals from one place to another, some times by accident or by leakages pollute the marine water.
4. Testing of atomic weapons, space aircrafts, missiles (generally developed country do this) and other radioactive wastes when dumped in seas, causes heavy loss to aquatic biota.
5. Harmful effluents from nuclear power stations or from other scientific organizations like BARC in India, chemical industries, fertilizers, Pesticide and insecticide industries when mixed in marine water causes harmful effects to marine life.
6. Marine pollution also caused by oil drilling in seas, tourism activities and heat released from industries. etc.

Effects of marine pollution:

The major effects of marine pollution are as follows:-

1. Oil is most dangerous pollutant when afloat on sea or mixed with water a great threat to marine life specially fish, birds, invertebrates and algae. Thousands of birds killed every year because once they oiled, seldom survived despite efforts to clean themselves.
2. Oil of sea also effects sensitive flora and fauna, phytoplankton, zooplankton and other animals. In Alaska, Brittany (France), Elbe (Germany) thousands of birds died by oil spillage.
3. Plastic or plastic materials when dumped into sea by commercial ships or from drainage, animal take it through their food in stomach. It causes ulcer and reduces hunger.
4. Marine pollution effects the food chain in seas. Serious diseases like cancer are the caused when affected animals are taken by man from ocean.
5. Detergents, either from cleaning up the spills or from drainage, also responsible for high mortality of marine life.
6. Heavy metals (like lead and mercury), factory materials, mineral oils, acids and other biocides are also measure threat to marine life when mixed with sea water.

Apart from these major effects, there is a heavy loss of economy after getting polluting animals and chemicals from marines.

Control of marine pollution:

The control of marine pollution can be studied in following two steps:-

1. **Steps already in operation**

(i) Port authorities are alert and introduced antipollutant measures by creating pollution cell. But deeper in sea coastal guards are doing this job.

(ii) Various research organizations, institutions are working in this field to check the marine pollution.

(iii) In most of the countries (India too), the monitoring and survey in operation to control the marine pollution.

(iv) Authorities are taken care of effective measures to check the oil leakage from ships and tankers.

(v) Urban and coastline corporations are trying to check the dumping of wastes from human activities & Municipal etc. solid waste management is helping to recycle or reuse.

Suggesting steps to control marine pollution

(1) Dumping of oil ballest, hazardous and toxic substances, gases from radioactive labs into sea, should be banned or should be properly treated before dumping.

(2) Drainage, sewage sludge and effluents from industries should not be discharged in to rivers which joins sea.

(3) Developmental activities on coastal areas should be minimised.

(4) Toxic pollutants from industries and treatment plants should not be discharged into sea.

(5) Ships and ports should have certain facilities for reducing pollution.

(6) Certain biological and other methods should be followed to restore species diversification and ecobalance in the water body to prevent pollution.

(7) Effective measures should be developed to check the leakage in ships and oil tankers.

(8) Nuclear explosions and other nuclear activities in sea should be minimized.

(9) Wastes from municipal, industries, sewage and thermal power stations should be recycled for reutilization. Such plants should be developed. Some are in operation.

(10) We should develop awareness in people to reduce the amount of waste in their daily life.

(11) Drilling should not be allowed in coastal areas.

NOISE (SOUND) POLLUTION

INTRODUCTION :

The term 'noise' may be defined as an unwanted sound at a wrong time and a wrong place. Although noise is undesirable. It could be meaningful or meaningless. A meaningful noise is generally meant for inviting attention or expecting a consequent response such as the cry of a baby or a screaming of a person for help. On the contrary, in irresponsible or meaningless noise is disturbing and annoying. Whether a given sound is wanted or unwanted may depend upon the person involved, the loudness, the rhythm, and the length of time for which one is exposed to it. A sound may be music to one person but noise to another; acceptable when soft, rhythmic or for short time, but unacceptable when loud, random or prolonged; reasonable when made by himself but unreasonable when it is made by other. However, prolonged and loud sound is generally considered as noise which is mostly caused because of industries, vehicles, aeroplanes etc. Sound is a special kind of

wave action which is usually transmitted through air in the form of presence waves. These waves are received by hearing approaches of animals, including man transformed in to electrical impulses in the ear and carried to the brain which enables us to hear.

Sound has several physical properties among which " Frequency" and "Intensity" are the most relevant for the present discussion. Sound frequency is the rate at which compression waves arrive at or pass a fixed point. "Pitch" is the human perception of sound frequency (and also intensity to some extent). Sound intensity is the acoustical power (i.e. the energy delivered by sound) per unit area. "Loudness" is the human perception of the sound intensity (and also frequency to some extent). "Hertz´(Hz) or cycles per second is a measure of sound frequency. Human beings can hear only sounds ranging from 20 Hz to 20,000 Hz. The range of frequencies of human speech is 200 to 3000Hz, which is best heard by humans. Thus we can hear only sounds of certain frequencies and even among them, we are more sensitive to some than to others. Sounds too high in frequency (above 20,000 Hz) is called "ultrasound" and that which is too low in frequency (below 20 Hz) is called "infrasound".

The response of ear to sound is proportional to the logarithm of its intensity or pressure. The loudness of two sounds is judged subjectively by the ear by the ratio of their intensities or pressures. The loudness is expressed in terms of a unit called "decibel" ("deci" comes from the Latin word for ten, and a "bel" is "the" logarithm of ratio" of any two acoustical or electrical intensities. In terms of sound, a "decibel" (dB) is ten times the logarithm of the ratio of two sound intensities, one being the intensity of any sound of interest and the other being a reference sound (I).

$$\text{Decibel (dB)} = 10 \log \frac{\text{Sound intensity measured}}{\text{Reference sound intensity}}$$

In the United States, the Reference sound intensity is 10^{12} watts per square meter, which is the sound intensity barely audible to human beings. This zero dB is the threshold of hearing. Thus, a sound which is 100.000 times louder (more intense) than the reference level would be called a 50-dB sound (because the logarithm of 100,000 is 5 and 10 times 5 is 50). Similarly, sound with 10 times the intensity of the reference level would be a 10 dB sound. A normal conversation is done at 60 dB sound levels. A jet plane during its takeoff produces a 150 dB sound. The decibel scale for some familiar sound sources is given in Table 5.5. The psychological and physical harm at different decibel levels is shown in Table 5.6.

Table 5.5. The Decibel Scale

Sound Source	*Decibel, dB*
Launching of space rocket	170
Jet plane at take off	150
Threshold of pain	140
Pneumatic riveter	130
Running motor cycle	118
Jet fly over at 150 m	115
Rock band	111
Jet fly over at about 300	103
Farm tractor	98
Motor cycle at 25 ft	90
Heavy city traffic	85
Alarm clock	80
Average city traffic	70

Normal conversation	60
Business office or light city traffic	50
Living room	45
Library	35
Broadcasting studio or A quiet room at night	20
Rustling of leaves	10
Threshold of hearing	0

Table 5.6. Psychological and Physical Effects at Different Decibel Levels

135 dB	..	Painful
110 dB	..	Discomfort
88 dB	..	Hearing impairment on prolonged exposure
80 dB	..	Annoying
65 dB	..	Intrusive

Effects of Noise

(a) Physiological Effects:

The acute effects caused by noise depend upon the pressure and frequency. At high levels of about 150 dB, immediate permanent hearing impairment may be caused. At sound levels in the range of 120-150 dB, effects on respiratory system, dizziness, disorientation, loss of physical control, other physiological changes resulting from stress, nausea and vomiting may be caused. Even sounds of the order of 70 dB can have measurable physiological effects, although they may not result in any immediate impairment.

Loud sounds can cause an increased secretion of many hormones of the pituitary gland e.g., adrenocorticotropic hormone (ACTH). ACTH in turn stimulates the adrenal gland, which secretes several other hormones. Through a variety of influences, these hormones in turn trigger various effects such as (a) enhancement of the sensitivity of the body to adrenalin, (b) increase of blood-sugar levels (c) suppression of immune system and (d) decreasing the efficiency of liver to detoxify blood.

(b) Psychological effects

Although there is little specific evidence regarding the onset of mental or nervous illness caused by noise, some reports are available to indicate temporary effects such as deterioration in concentration and even mental disorientation at high noise levels.

Loud continuous noise reduces the working efficiency, interferes with communication, increases the frequency of errors which may, at times, cause accidents. Noise reduces the mental capability. Noise has psychological effects on humans ranging from mild distress to complete unhinging.

Noise interferes with deep sleep and interrupts sleep. Because sleep is important to emotional stability, noise may contribute to distress and emotional disturbance. Noise also aggravates any existing psychological conditions and mental illness.

(c) Hearing Loss

Prolonged exposures to loud noise can cause temporary or permanent loss of hearing. People working in noisy places such as industrial establishments, factories etc. Often suffer from temporary loss of hearing. The ciliary cells in the inner ear are inactivated or numbed and the threshold of hearing of the subject is raised. If the loudness of noise is moderate or the duration of exposure is short, the damage is only temporary. The auditory system recovers itself when the exposure ceases. In Audiometric tests, the phenomenon is referred to as **Temporary Threshold Shifts** or **TTS**.

Longer exposures to louder noises may cause permanent shift in the threshold of hearing of an individual. The individual in such cases suffers from partial but permanent loss of hearing. He is no longer able to hear low sounds which are audible to normal persons. This is caused by slow and chronic damage to ciliary cells in the inner ear. Still, medical science is of little help in such cases.

Very loud, sudden and impulsive noises, such as a bomb blast, are capable of causing acute damage to auditory system and an abrupt loss of hearing. With or without involvement of inner ear, it is the middle ear which is affected in most of the cases. High intensity sound waves damage the ear drums and may disrupt the delicate bony chain which carry sensation from ear drums to the inner ear. Very fine surgical techniques have been developed to restore the hearing ability where only middle ear is involved.

(d) **Other health effects of noise pollution**: Loud noise is nuisance which affects sleep, concentration and work or performance of an individual. Work which needs a high degree of skill and precision is considerably affected. It may cause headache, irritability and fatigue. It is interesting to note that our optical system is considerably affected by noise pollution. Dilation of pupils, impairment of night vision, decrease in colour perception ability are some of the effects caused by exposure to loud noise for long durations.

Noise affects our cardiovascular system also. Loud noises tend to decrease the output of blood from heart, cause arterial blood pressure to fluctuate and smaller blood vessels of the body constrict reducing the flow of blood to the organs concerned. Heart beat rate is affected. Changes in breathing amplitude have been reported due to sudden and impulsive noises. Eosinophilia, hyperglyaemia, hypokalaemia and hypoglycaemia may also be caused by changes in blood circulation and other body fluids due to noise pollution (Kryter, 1970).

(E) Prevention and Control of Noise Pollution

Loud noise is the form of pollution which often causes much public concern. Therefore, necessary steps have to be taken to control the nuisance. Some of these are :

1. **Reduction of noise at the source of its origin:** Often a little precaution can reduce much of the nuisance caused by loud noise. This can be achieved by replacement of noisy rattling devices or machines with quieter ones. Noise level can be reduced effectively by replacement of noisy and rattling parts, providing better cushioning to check the vibrations, proper oiling and greasing to ensure smooth running and using effective silencers etc.

2. **Application of sound proofing techniques to muffle down loud noises:** Sound waves are absorbed by porous material such as perforated sheets and other objects. Just as putting cotton plugs in the ears reduces noise level for the individual concerned, sound barriers placed around the source of origin of loud noises drastically reduce the intensity of sound on the other side of the obstacle. For example, little of loud noise produced in picture halls and auditoria escapes out because of effective sound proofing and acoustic techniques are applied for the purpose. The same can be done for industrial units also.

3. **Keeping residential localities free of noisy industries, busy highways, aerodromes etc.**

Residential localities should be established away from noisy industries, busy highways, aerodromes or else these noisy establishments should be developed away from quiet residential areas. Industrial units can be displaced to some industrial area whereas by passes may be developed to divert busy railway tracks and highways away from domestic establishments. Only that part of traffic should be allowed to get into a residential area which is barely necessary. This shall curb much of the nuisance caused by noise pollution.

4. **Enactment of strict legislation and its effective compliance**: In most of the countries including our own, legal framework against noise pollution has been developed. However, in most of the cases little efforts are made to enforce these rules and regulations effectively. If we ensure

only effective compliance of these rules much of the nuisance of noise pollution shall automatically be curtailed.

5. Noise control methods in industrial plants

Excessive noise is produced from various types of machines, petrol and diesel engines, electric motors, construction site equipment, pumps and pumping systems, compressed air systems, hydraulic systems, air distribution system, industrial fans, etc. It is always advantageous, economical and effective to identify the noise sources and noise problems right in the design and erection stages and incorporate the necessary noise control measures rather than attending to the problems at a later stage.

The various noise sources in industrial plants and the methods available for noise control are summarized.in Table 5.7: given below:

Table 5.7: Typical Noise Sources in Industrial Plants and Methods of Noise Control

Equipment	*Noise Source*	*Methods for noise control*
Bulldozer, crane, compactor, excavator, dumper, shovel, scraper, etc.	Engine.	Fitting of more efficient silencer or exhauster, closing the enclosure panels, if fitted.
Rotary drills, diamond drilling and boring	Drive motor and bit.	Use of machines inside acoustic covers.
Riveters.	Impact on rivet.	Enclose the working area in acoustic screen.
Pumps	Engine pulsing.	Enclosure in acoustic screen, allowing for engine cooling and exhaust, use of antivibration mounting, flexible couplings and hoses, maintaining adequate inter pressure.
Motors	Cooling fans	Intake muffler, unidirectional fan.
	Cooling systems.	Absorbent duct liners
	Electrical motors.	Enclosure
Engines.	Air intake and exhaust.	Use of mufflers
	Cooling fan.	Enclosing intake and discharge lines, use of quieter fan
Vibrating screen.	-	Stiffening and damping.
Pneumatic equipment	Air and steam vents.	Use of mufflers: quieter valves
	Air jets	Use of mufflers, limiting of air velocities, improving orifice design.
	Ducts.	Lagging, adsorbent lining, limiting of air velocity.
Furnaces	Combustion	Use of acoustical plenum: seals around control rods.
	Ducts	Lagging, use of mufflers.
Turbines	-	Use of enclosure, use of intake and outlet mufflers.

Compressors.	Discharge piping and expansion joint.	Lagging and use of in-line muffler.
	Air intake and exhaust.	Use of mufflers
	Intake piping and suction drum	Lagging.
	Speed changers.	Enclosure or constrained damping on case.

Approaches for Noise Control

The following four approaches are available for noise control :

(1) Modifying some of the present practices and procedures in order to minimize the noise.

Ex:Reducing automobile traffic, outlaying sirens, discouraging stereos without headsets, using glue instead of rivets, etc.

(2) Shielding the sources of noise generation.

Ex: Use of sound-absorbing motor mountings, better installation, better design, use of motor enclosures, use of vibration damping or absorbing materials in automobiles and dishwashers, etc.

(3) Shielding the noise receiver.

Ex: Using earplug, control booths, etc.

(4) Shifting noisy sources and things away from people

Ex: Isolating airports, industrial complexes, etc.

Obviously, some of the above measures can be implemented successfully only if they are mandatory.

THERMAL POLLUTION

The term Thermal Pollution has been used to indicate the detrimental effects of heated effluents discharged by various power plants. It denotes the impairment of quality and deterioration of aquatic and terrestrial environment. Various Industrial plants like thermal, atomic, nuclear, coal fired plants oil field generators and mills utilize water for cooling purposes.

The heated effluents are discharged at a temperature 8 to 10^0 C higher than the temperature of intake waters, which reduces the concentration of D.O. (Dissolved Oxygen).

Thermal Pollution: It can be defined as:

1. The warning up of an aquatic system to the point where desirable organisms are adversely affected.

2. Addition of excess of undesirable heat to water that makes it harmful to man, animal, plant or aquatic life or other wise causes significant dangers to the normal activities of aquatic communities in water.

3. Heated effluents either from natural or man made sources, contaminated with water supplies, may be harmful to life because of their toxicity, reduction in Dissolved Oxygen (D.O.), aesthetically unsuitable and spread diseases.

4. It reduces the number of aquatic species and destroys the balance of life in streams as is evidenced by the biological indices of community and diversity.

5. It is a by-product of rapid and unplanned industrial progress and over population.

SOURCES OF THERMAL POLLUTION

The accelerated pace of development, rapid industrialization and extensive population density have increased demand of thermal power plants. Human activities, today, are constantly adding pollutants to air and water at an alarming rate. The following sources contribute to thermal pollution:

1. **Nuclear Power Plants**: Nuclear power plants, including drainage from hospitals, institutes, nuclear experiments and explosions, discharge a lot have unutilized heat and trapped radionuclides into nearby water streams. Emissions from nuclear reactors and processing instruments are also responsible for increasing the temperature of water bodies. Heated effluents from power plants are discharged at 10°C higher than the coolant receptor and severely affect the aquatic flora and fauna.

2. **Coal-fired Power Plants:** Some thermal power plants ultimately discharges effluent having temperature difference of 15°C between effluent and water body. The Thermal power plants utilize coal as fuel and they constitute the major source of thermal pollutants. The heated coils are cooled with water from nearby like or river and discharge the hot water back to the receptor water body and thereby increasing the temperature of the nearby water. The heated effluent decreases the dissolved Oxygen content of water. It results into killing of fish and other marine organisms.

3. **Industrial Effluents:** Industries generating electricity, like coal as fuel and Nuclear powered thermal plants, require huge amounts of cooling water for heat removal. Other industries like textiles, paper and pulp as well as sugar also release heat in water but to a much lesser extent. The heat from the turbo-generators installed in industries have temperature of effluent as 5°C to 9°C more than the normal temperature of stream. To cope with the increased demand of electricity and rapid industrialization the number of installations are raised which results in discharge of more volume of water/heated effluent and above the receptor water body temperature.

4. **Hydro-electric Power:** The generation of hydroelectric power, sometimes, results in negative loading in water systems. Apart from electric power industries, various factories with cooling contribute to thermal loading. It has been reported that about 18% more heat is given to cooling ponds in nuclear power plants than any other plant of equivalent size.

5. **Domestic Sewage**: Domestic sewage is commonly discharged into rivers, lakes and canals with or without waste treatment. The municipal sewage normally has a higher temperature than receiving water. The discharged water not only raises the stream temperature to a measurable extent but also creates numerous deleterious effects on aquatic biota. The organic matter present in the sewage utilizes the dissolved oxygen present in the surface water for oxidation. With the increase in the temperature of the water, the D.O. content decreases and the demand of oxygen increases. Hence, the anaerobic conditions will result in the release of foul and offensive gases. The marine life dependent upon the D.O. will die out and the quality of water is also adversely affected.

EFFECTS OF THERMAL POLLUTION: The various effects of the thermal pollution are:-

1. **Reduction in Dissolved Oxygen**: Concentration of dissolved oxygen decreases with increase in temperature of water. For example, the D.O. content is 14.6 ppm in water at a temperature of 32°F and 6.6 ppm at 64°F. Thus cold-water fish, which requires about 6 ppm to survive, would not tolerate the high water temperatures. If they remained in the area they would die of oxygen starvation. Since the aquatic biota live acrobically, so a healthy stream should have an adequate supply of dissolved oxygen.

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

3. **Increase-in Toxicity:** The rising temperature increases the toxicity of the poison present in water. A 10°C rise in temperature doubles the toxic effect of Potassium cyanide, while an 80°C rise in temperature triples the toxic effect of O-Xylene causing massive mortality of fish.

4. **Interference with biological Activities:** Temperature is considered to be of vital importance to physiology, metabolism and biochemical process in controlling respiratory rates,

digestion, excretion and overall development of aquatic organisms. The temperature changes totally disrupt the entire ecosystem. Sharp changes in temperature are often destructive. Because, the life of aquatic animals involves several chemical reactions and the rate of these reactions vary according to changes in temperature.

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

6. **Variations in Reproductive Rate:** The increase in temperature triggers deposition of eggs by female. The triggering is particularly dramatic in estuarine fish, which spawn in four hours after the water temperature reaches critical level.

7. **Changes in Metabolic Rate:** Fishes show a marked rise in basal rate of metabolism with temperature to the lethal point. The respiratory rate, oxygen demand, food uptake and swimming speed in fishes increase.

8. **Increased Vulnerability to disease:** Activities of several pathogenic microorganisms are accelerated by higher temperature. Hot water causes bacterial disease in certain fishes such that they fail to develop eggs above critical temperature.

9. **Invasion to destructive organisms:** Thermal pollutants may permit the invasion of organisms that are tolerant to warm waters and highly destructive e.g. invasion of ship worms into New Jersey's Oyster Creek.

10. **Undesirable Changes in Algae Population:** The life in an ecosystem is greatly influenced by the algal growth. Excess nutrients from the washout waters from farmlands, thermal plants cause an excessive algal growth with consequent acceleration of eutrophic and other undesirable changes.

11. **Destruction of Organisms in Cold Water:** The volume of water required for cooling purposes from a stream is enormous. Unfortunately many of plankton, small fish, insect larvae that are sucked into the condenser along with cooling water are killed by the thermal shock, increased pressure and water viscosity.

12. **Biochemical Oxygen Demand**: When the temperature of stream carrying biodegradable organic matter rises, the intensified action of aquatic organisms causes B.O.D. to be accomplished at a lower temperature. When the temperature of stream carrying biodegradable organic matter rises fish death may occur due to synergistic action, which is caused due to accelerated chemical or biochemical action.

13. **Effect on Marine Life:** Temperature plays an important role in affecting the physiology, metabolism, growth and development of marine animals. Sea organisms are poilkilothermic i.e. their body temperature varies with the surrounding water. Some marine creatures cannot tolerate wide changes of temperature, so they die at higher temperature.

14. **Effect on Bacteria:** Due to the heated discharges from the industries and plants (industrial), the bacteria are severely damaged. The effect includes coagulation of body Protein, melting of cell fats, toxic action of metabolic products etc.

CONTROL OF THERMAL POLLUTION

Heat must be removed from the condenser cooling waters prior to their disposal into water bodies. The major principles involved in the process of heat loss are:-

1. Conduction
2. Convection

3. Radiation
4. Evaporation

The following methods can be adopted to control high temperature caused by thermal discharges:

(1) **COOLING PONDS:** The cooling towers are beneficially used in dissipation of heat as shown in fig.5.1.

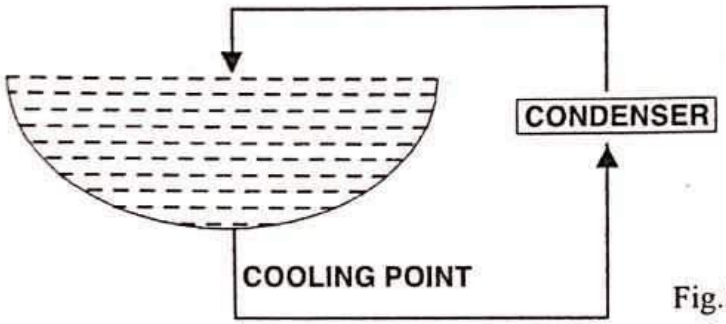


Fig.5.1

The water from the condensers is stored in the earth like ponds where natural evaporation brings down the temperature. The water is re-circulated again. Another method for installation of cooling ponds is shown in fig.5.2.

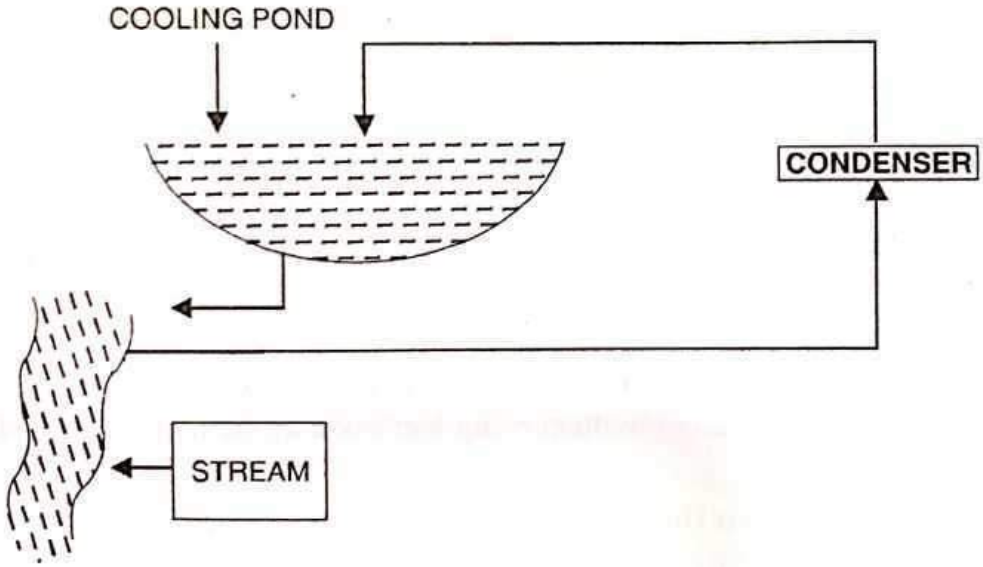


Fig.5.2

(2) **SPRAY PONDS**: In spray ponds, the water is sprayed in the cooling ponds with the help of spray nozzles to convert it into fine droplets which provide more surface area to facilitate efficient heat transfer to atmosphere.

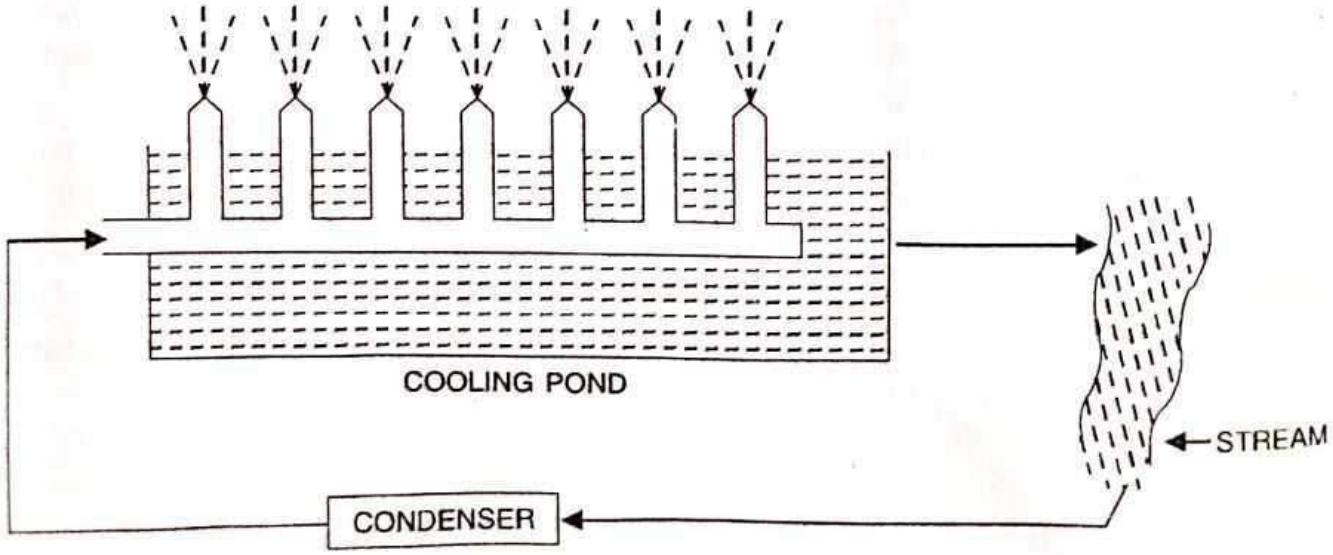


Fig.5.3

(3) **COOLING TOWERS:**

Wet Cooling Towers: In wet cooling towers, the heated water is brought in direct contact with continuously flowing air. The evaporation brings down the temperature. To increase the surface area of contact, the water is broken down into droplets by use of spray nozzles or by splashing it on the packing or baffles in the cooling towers.

(4) To handle large quantities of heated effluents, large tanks or reservoirs should be constructed to retain the water for a little longer time. When water cool down to a tolerable temperature, it may be released.

(5) The heated effluents discharged from the chemical industries and thermal power plants can be put in to certain beneficial uses like green house, frost protection during colds, aquaculture, heating the buildings etc.

NUCLEAR HAZARDS

Hazard mean dangerous to human being or so by external source. This external source is from environment. When our environment is polluted then no one can escape from the pollution hazard. It has become a part of our life. A number of atoms possess the ability to limit radiations and thereby cause radioactive pollution. Radiations originate from instability of the nuclei of an atom which loses sub-nuclear particles and energy to acquire a stable state i.e radioactivity. It is the state of nuclei which is responsible for the phenomenon. Neutrons and protons constitute the nucleus while electrons revolve round the nucleus (units outer orbits). When the member of protons are equal to number of electrons, the chemical properties shall remain the same. Neutrons and protons constitute the mass while electrons constitute change to the element. Thus *Radioactive element* is defined to be the collection radioactive mass with the same change of the nucleus. The radioactive atom has the same change of the nucleus and the same mass is called *Radioactive isotope*. The *Radioactivity* of a radioactive substance is expressed by the number of nuclear transformations in unit time.

A radio isotope is characterized by the following properties:-

(*i*) Half life period. (*ii*) Mode of decays.

(*iii*) Energy of radiations (*iv*) Definite energy state

Radiation is the emission of rays and particles or release of energy from the source (atom). There are two types of radiations ionizing and non-ionizing radiations. These radiations destroy the organic molecules of which the body cells are composed. If ion pairs enter into a living protoplasm, they damage it and the damage is proportional to the number of ion-pairs absorbed. The following types of radiations are given out when an element transmutates or decays.

(i) **Emission of alpha (α) particles**. Alpha particles are nothing but Helium nuclei. Emission of alpha particle will change into elements of lower atomic number. These are deflected by electric and magnetic fields. They are to show moving, strongly ionizing, weakly penetrating and stopped by 80 mm of air.

(ii) **Emission of Beta particles**:- **(β)** Emission of Beta particle changes into another element with a higher atomic number. Beta particles are high velocity electrons. Strongly deflected in electric and magnetic fields. The penetrating power of Beta particles varies with the energy of particles.

(iii) **Emission of Gama rays (γ).** These are high energy electromagnetic radiations. Can penetrate several cm. of Lead sheet depending upon the energy. These are undeflected in magnetic fields.

Radioactive decay is a spontaneous process arising from nuclear instability.

Sources of Radio Active Pollution

The two main sources of radioactive pollution are, natural and manmade.

NATURAL SOURCES

The natural sources of radioactivity are considered mainly of the cosmic radiation received from the space, and the naturally occurring radioisotopes present in the environment and those contained within the body of the organisms. The cosmic radiations are of extraterrestrial origin, which probably arise from the sun or even beyond it. They are consisted of particles of very high energy, primarily of protons and some heavy nuclei. These cosmic particles collide with the gas molecules of the upper atmosphere bringing about intense ionization in gases accompanied with the formation of secondary cosmic rays composed mainly of neutrons, mesons, and gamma rays. Eventually a complex mixture of particles reaches the earth as cosmic rays. These particles also form substantial quantities of 3_H and 14_C in the atmosphere.

Another source of natural radiation is the presence of radionuclides in the lithosphere, hydrosphere and atmosphere. All the elements above atomic number of 82 (Lead) are radioactive in nature and emit a variable quantity of radiations. The most abundant naturally occurring radionuclides on the earth are Uranium, Thorium and Potassium-40. Soils, rocks and even building material contain small quantities of 40_k; and Uranium and its daughter elements.

Man-Made Source

Man causes radioactive pollution by testing of nuclear weapons, establishment of nuclear power plants, mining and refining of plutonium, and thorium, and preparation of radioactive isotope.

1. Nuclear weapons

Testing of nuclear arms comprises:

(a) The use of Uranium 235 and Plutonium 239 for fission.

(b) Hydrogen or lithium as fusion material.

Atomic explosions are uncontrolled chain reactions. They give rise to very large neutron flux conditions that cause other materials in the surrounding environment to become radioactive.

Huge clouds of fine radioactive particles and gases are thrown up in the environment and are carried away to distant areas by the agency of wind. Gradually they settle down on earth as fall out or are brought down by rain.

2. Atomic Reactors and Nuclear Fuel

The most common fuel used for fission in the nuclear power plants are uranium, thorium and plutonium. Uranium undergoes several processes, right from its mining to its inception into the reactors. The spent materials obtained from the reactors, after the energy has been utilized, are reprocessed to recover unburnt uranium, plutonium and some other important isotopes, which can be used in medicine or for some other useful purposes. The whole operation from the mining of the fuel to its final disposal is called "nuclear fuel cycle".

At almost all stages of the nuclear fuel cycle, liquid, gaseous and solid radioactive wastes are released having a tremendous potential to contaminate the environment and hence, a great care is to be taken for the environmental safety during the nuclear operations.

3. Radioactive Isotopes

Radioactive isotopes such as 125_I, 14_C and 32_P and their compounds find wide usage in scientific research institutions contain varying amounts of radioactive materials. When this waste water reaches the different water sources such as rivers, streams, lakes etc. through the sewers they cause water pollution. Radioactive iodine and phosphorus also enter the food chain through water and may finally reach man through fish etc.

4. Other Sources

During different medical treatments, varying concentrations of radiations enter the human body for instance, X-rays are common for detecting skeletal disorders, and therapy for cancer patients often includes radium and other isotope radiations.

It has been reported that about 240 million dental and medical X-rays are taken annually and that 15 million tests using radioactive materials as tracers in the human body are also made.

A common type of ionizing radiation is X-ray which is produced by radiographic equipment. X-ray therapy equipment, dental X-rays that can operate at a voltage about 10 KV produce more penetrating radiation and may be more hazardous, if not properly shielded.

Damages to a Biological System

Most of the damages caused by radioactive pollutants stem from their capacity to produce high energy radiations, which are very harmful to a living system. There are two main modes in which radioactive pollution can be dangerous to a biological system.

(i) Damages caused by radiations from outside source.

(ii) Damages caused by radiations from sources inside the body.

Damages caused by Radiations at different levels

(i) Damages at Molecular level

Damages to macromolecules such as enzymes, DNA, RNA etc. through ionization cross-linkages within and between two affected molecules.

(ii) Damages at sub-cellular level

Damages to cell-membranes nuclei, chromosomes such as fragmentation, mitochondria etc.

(iii) Damages at cellular level

Inhibition of cell division death, decay and transformation to malignant state.

(iv) Damages to Tissues and Organs

Disruption of such systems as central nervous system, loss of sight, inactivation of bone marrow activity resulting in blood cancer malignancy and ulceration of intestinal tract.

(v) Damages to an Individual and whole population

Death or shortening of life due to radiations changes in characteristics due to mutations. In human beings exposure of radiations results in little visible effects in early stages. But after 12-24 hours injury symptoms manifest themselves. This includes reddening of skin, anemia, anorexia. Vomiting, and diarrhoea and with heavy doses, blister formation, pigmentation of skin, burning sensation all over the body, loss of sight etc. It must be noted that for all this there is no cure available. Once a person is exposed to radiation he has to bear its consequences. Medical aid can do little.

HAZARDS ASSOCIATED WITH RADIO ACTIVE POLLUTION

Radio-active pollutants are not like other pollutants which are sooner or later converted into harmless material and degraded into simpler constituents to be recycled into the ecosystem and used again. It is not the element itself, but the instability of its nuclei which is responsible for damages caused by these pollutants. As long as radiations continue, these wastes are dangerous for the living beings. After the emission of radiations nuclei attain stable state and behave like any other element in the environment or the biosphere. Life on earth's crust could evolve only when the nuclear activity ceased, atoms acquired stable state and radiations were reduced to the level which could be tolerated by living beings. Major hazards associated with radio-active pollution can be summed up as follows:

(1) No physical, chemical or biological process can influence the process of radio active emissions. The unstable nuclei have to decay and acquire a stable state.

(2) A number of radio-active isotopes have a very long half-life. Thorium-232 ($_{90}Th^{232}$) takes 14,0000,000,00 years to lose half of its radio-activity. Half of Uranium-235 ($_{92}U^{235}$) takes 710,000 years to disintegrate. Half of Neptunium-237 ($_{93}Np^{237}$) decays in 21,00,000 years. This makes these radio-active wastes almost a permanent hazard for the biosphere.

(3) Most of the radiations have a high penetrating power. Thick sheets of steel, cement concrete walls etc, can not contain them. They can easily penetrate to deep seated organs and cause injury.

(4) Nucleic acids (DNA and RNA) effectively absorb these radiations. Even low level radiations which do not cause any visible damage are completely absorbed by nuclear material which causes carcinogenic, mutagenic and teratogenic effects.

(5) A biological system is unable to distinguish between a radio-active and a normal isotope of an element as their physical and chemical properties are similar. Radio-active isotopes are therefore, absorbed and incorporated within the bodies of living organisms as normal isotopes are. This lodges a radio-active source within the body of the organism itself.

(6) Like any other element radio-active isotopes are also absorbed, accumulated and bio-magnified thousands of times. Thus the entire food chain becomes contaminated. Organisms at higher trophic levels may, therefore, receive a highly concentrated source of radio-active material through their food supply.

(7) There is no other way to dispose off these hazardous wastes except to store them for thousands or millions of years away from living beings. This is too long a period on human scale of time. Even the safest burial places for radio-active wastes, which represent the best of human efforts, have shown signs of leakage. At present it appears very difficult, though not impossible to store radio-active wastes away from the biosphere for such long periods.

(8) In spite of all these hazards, nuclear reactors and tests are still continuing and an increasingly large amount of radio-active wastes is accumulating every day while no solution to the problem of their safe disposal is in sight till date.

The *harmful effect of radiation* upon human beings is due to its ability to wise and ultimately destroy the organic molecules of which body cells are composed of. The damage depend upon, the energy and the type of radiation. The energy is expressed in **Rads** (i.e. absorption of 100 ergs or 10^8 joules of energy per gram of tissue). The total biological effect of radiation expressed in **Rems.**

Number of rems = n × Number of rads

Where n = 1 for β, γ and x-rays.

= 10 for α radiations or high energy neutron.

Control of Radioactive Pollution

Control of natural radioactive pollution may not be possible. Out of all the sources, only artificial radioactivity is the scope of intervention, wherever controls can be thought of. Radioactive pollution can be controlled by strict enforcement of the following safety measures.

All low or high level wastes have tremendous capacity to pollute the environment. As low level wastes are often produced in large quantities, their containment is not possible. They are visually subjected to a treatment for removal of radioactivity and then discharged in the water bodies or on land in usual way. High level wastes, on the other hand, cannot be disposed of freely in the environment, but have to be concentrated, contained and stored out of the reach of human's environment.

The radioactive wastes concerned with water pollution are usually in liquid or solid state. These different kinds of wastes pose various problems, as disposal techniques suitable for one kind may be risky for other. All techniques however have a single goal that radioactive constituents of wastes are not allowed to cause harm to organisms and in particular humans.

SOLID WASTE MANAGEMENT

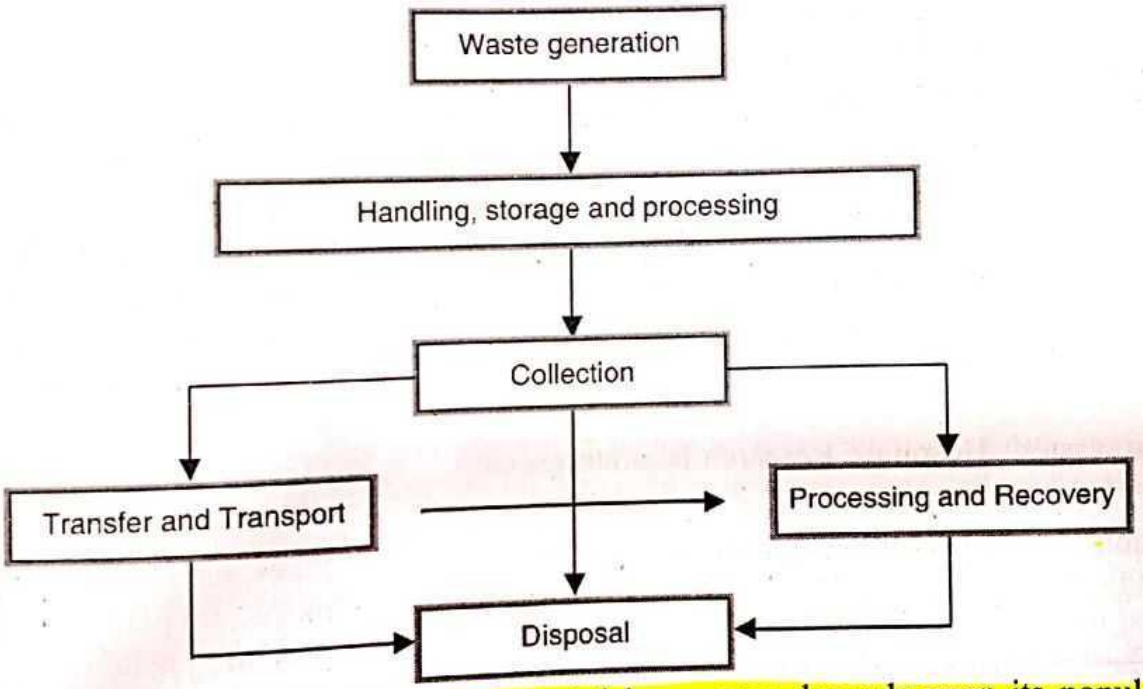
Any material that is thrown away or discarded as useless and unwanted by human or from animal activities is considered as solid waste. In earlier period, the disposal of solid waste was simple but now a days it is a great challenge. The management of waste is the fundamental concern of the activities encompassed in solid waste management. The purpose of the study of solid wastes is to –

(i) Identify the various types of solid wastes and their sources.

(ii) Examine the composition of wastes.

(iii) Consider the elements involved in their management.

The activities involved with the management of solid wastes from the point of generation to final disposal have been grouped in to six Functional Elements –



The total quantum of solid waste generated in an area depends upon its population and urbanization. Solid wastes generation is directly related with income. Higher the income greater is the waste generation.

Sources of solid wastes

Sources of solid wastes can be clarified in to following categories:-

1. Residential
2. Commercial
3. Municipal
4. Industrial
5. Open areas
6. Treatment plants
7. Agriculture
8. Hazardous wastes
9. Construction sites

Details of the above is given in this table:-

Table 5.8 Sources of solid wastes

Source	*Location—Wastes are generated*	*Types of solid waste*
Residential	Single-family and Multi-family Houses, low-medium and high rise apartments, etc.	Food wastes, rubbish, ashes, special wastes.
Commercial	Restaurants, Markets, Stores, hotels Institutions, office, Workshops etc.	Food wastes, rubbish, Ashes, demolition and construction wastes, special wastes.
Industrial	Construction, Fabrication, Light and heavy manufacturing, chemical plants, Mining, power plants, deduction, etc.,	Food wastes, rubbish, ashes, demolition and construction wastes, special wastes, hazardous wastes.
Open areas	Sheets, parks vacant lands, playgrounds, beaches, etc.	Special waters, rubbish.
Treatment	Water, wastewater and industrial treatment processes, etc,	Sludge
Agricultural	Field and row crops, orchards, dairies, feedlots, farms, etc.	Spoiled food wastes, agricultural wastes rubbish, hazardous wastes.
Municipal	Courts, offices, schools, colleges, hospital, parks, playgrounds, banks etc.	Food wastes, rubbish, ashes, demolition wastes, street sweepings, dead animals, road side litter, paper cuttings, glass, leather etc.
Hazardous wastes	Hospitals, Research laboratories etc.	Metals, substances and their solutions, washings etc.
Construction	Demolition and construction sites	Pipes, lumber, masonry brick pieces, tin plates, Roofing and insulating material etc.

TYPES OF SOLID WASTES:

Garbage: Food wastes are the animal, fruit, or vegetable residues resulting from handling, preparation, cooking, and eating of foods. It is also known as garbage.

Rubbish: Rubbish consists of combustible and non-combustible solid wastes of households, institutions, commercial activities, etc, excluding food wastes or other highly pursuable materials.

Ex, Combustible-Paper, Cardboard, Leather etc.,

Non-Combustible -Aluminium cans, tin cans, glass etc.

Ashes and Residues:

Materials remaining from the burning of wood, coal coke and other combustible wastes are categorized as ashes and residues.

Demolition and Construction wastes:

Wastes from buildings and other structures are classified as demolition wastes. Wastes from the construction, remodeling, and repairing of individual residences, commercial buildings, and

Special Wastes:

Wastes such as street sweepings, roadside litter, catch basin debris, dead animals and abandoned vehicles are classified as special wastes.

Agricultural Wastes

Wastes and residues resulting from diverse agricultural activities-such as the planting and harvesting of roe, field, and tree and vine crops, the production of milk, the production of animal for slaughter, and the operation of teed lots are collectively called agricultural wastes.

Hazardous wastes:

Chemical, biological, flammable, explosives, or radioactive waste that are harmful to human, plant or animal life are classified as hazardous wastes.

Collection of Solid Wastes:

Collection of solid wastes in urban areas is difficult and complex because the generation of residential and commercial-industrial solid wastes is a diffuse process that takes place in every home, every apartment building, and every commercial and industrial facility as well as in the streets, parks, and even the vacant areas of every community. The mushroom like development of suburbs all over the country has further complicated the collection task.

As the generation patterns become more diffuse and the total quantity of waste increases, the logistic problems associated with collection become more complex. Although these problems have always exist to some degree, they have now become more critical because of the high cost of fuel and labour. Of the total amount of money spent for the collection, transportation, and disposal of solid waste in 1975, approximately 60 to 80 percent was spent on the collection phase. This fact is important because small percentage improvement in the collection operation can effect a significant saving in the overall cost.

Effects of Solid Wastes

The accumulation of waste at any place is a bad and risky situation. Varieties of micro-organisations like bacteria, fungi, viruses, worms etc creep in to the accumulated waste and start its decomposition. Later on they grow and increase in number.

Various types of germs develop in the waste. They reach us through air, water and food. Most of the infectious diseases like cholera, diarrhoea, dehydration etc. spread in these ways. Air pollution, water pollution and soil pollution are caused due to the accumulation of different types of wastes.

Harmful fumes from industries and other waste effects eyes, skin, historical moments etc. Asbestos particles from Asbestos Industry causes Asbestosis. Accumulation of heavy metal particles cause serious health hazards. Mercury can cause Mina Mata disease.

Wastes material when accumulated here and there disturbs the drainage system. Decomposing wastes reach underground and contaminate underground water and soil.

Improper disposal of Municipal wastes and throwing the household wastes here and there effects the community and themselves. This produces foul smell and breeds various types of insects. Industrial solid wastes are the sources of toxic metals and hazardous wastes, which effects the soil and water. Wastes some times caused the fire in farm and forests, which produce dioxins, furans and polychlorinated biphenyls. These causes the serious ailments like cancer and other chronic diseases. Wastes like cans, pesticides, plastics, batteries, cleaning solvents, radioactive matters, paper, scraps etc. which can be recycles, cause serious effects on mankind in one or other way. Animals are also effected by taking poisonous waste and polythenes.

Management of solid waste

Waste management is the collection, transport, processing or disposal of waste materials so as to reduce their effects on local environment and community. Because it can not be stopped absolutely.

Methods of solid waste disposal. There are following methods:-

(a) **Physical removal.-** It is generally done by manual activities like, collection of wastes and sorting out in to reusable, decomposable and non decomposable. Then disposal becomes easy. Dustbins should be used in homes, offices and dispose accordingly i.e. to kabadi or for reuse, recycle. Some Municipals are also doing such jobs.

(b) **Dumping-** Transfer of solid waste from place of collection to the site of disposal is called dumping. Corporations and Municipal bodies collect and dump them on some suitable and safe site located far away from human habitation.

(c) **Compaction and Bailing-** The solid wastes are often spread on a plane and hand surface and later pressed by bulldozer. This is called compaction. These compacted layers are rolled and piled. This is called bailing. Now such compacted and bailed solid wastes are dumped for decomposition.

(2) 3R or Reduce, Reuse and Recycle of solid waste

(A) Reduce of waste material- We should reduce the household waste by using maximum part of the goods. Before throwing out side, we should select the parts for Reuse/Recycle. When we purchase the things, avoid polythene and heavy packages.

Hazardous waste can be controlled by reduction at source. We should suggest friends, relatives to save all clean papers and other various means to save paper. Gaseous wastes are generally removed through combustion, absorptions and adsorption techniques. There should be proper co-operation and co-ordination among individuals, local bodies and Govt Institutions for proper waste management in an area. Reduced demand for any metallic product will decrease the mining of their metal and cause loss production of waste. Thus, every individual has a responsibility of creating less waste and managing its properly.

(B) Reuse of waste materials. After selecting the waste (which can be reused) use after the proper treatment. We should not use, cups, plates, utensils, napkins etc of paper. If they are of permanent nature, therefore, they can be reused after washing. Plastic bags, wrap, foils, rotten articles should not be used. We should use refillable lighters, containers, and other usable items. We should discourage use and throw policy. Sell or donate goods instead of throwing them out. Furniture, clothes and other repairable articles should be reused after repair instead of throwing. We should develop quality of borrow, share and rent in ourselves.

One should take lesson from poors, villagers who reuse their materials to the maximum due to their financial conditions. We should utilize paper of their optimum use.

(C) **Recycling of waste materials.** Sewar and other drainage systems are associated with sewage treatment devices that centralize toxic effects of sewage before releasing it to the local water systems. Principal operations of solid waste disposal incorporate composting, senitary, land filling, thermal process or incineration.

(i) **Sewage treatment.** It is done through following steps:-

(a) The sewage is sent through setting chambers, where lime is mixed with it. Thus it becomes neutralized and most of the sediment is removed.

(b) Neutralized sewage is passed through Upflow Anaerobic Sludge Blanket (UASB). Here, decomposable material is decomposed through bacterial activities in absence of oxygen. After that water is passed through aeration tanks where air and bacteria are mixed.

ROLE OF AN INDIVIDUAL IN PREVENTION OF POLLUTION

People say, one and one becomes eleven, eleven and eleven becomes one thousand one hundred eleven and so on ..... Then, why an individual can not do for pollution or so. People go with us, if one can start some meaningful project. Mahatma Gandhi was one, Sunder Lal Bahuguna is one, but we can have knowledge of their movements. Gandhi ji said – The soil is capable to fulfil the complete demands of people but can not fulfil the excess desire of people. Soil is mother of a man, then it is the duty of every individual to miscible with that rather destroy. We should not over exploit the nature. We have to control our necessities.

Pollution and poverty are complimentary to each other. Some time people forced to go with the path of pollution. Illiteracy is another factor in the prevention of pollution. Unlimited desires, selfishness, urbanization, industrialisation, deforestation, to increase the life style etc. are some of big factors which are main cause of pollution. For that the need is to understand first, apply then be a lesson for others. Gandhiji was not an environmentalist but was for the concept of sustainable development.

In short, an individual can do as following safety measures to prevent the pollution -.

(1) One should start first in the field of environmental awareness to protect the pollution.

(2) We should go place to place to teach the lesson of awareness and prepare volunteers.

(3) Give the message to save environment through papers, magazines, T.V. and radio.

(4) To promote for plantation and conservation of forest.

(5) To organize seminars, on the subject related to pollution.

(6) One should go in rural areas during festivals, functions, local gatherings, and religious occasions to convince people for prevention of pollution.

(7) Awareness is very effective in childhood, hence we should go to schools, organize rallies to teach the lesson of environment.

(8) World forest day, world environmental day and other such function should be organized for general awareness. On these functions, Govt. should also take interest in this regard but we should not depend on Govt.

(9) Population growth should be reduced.

(10) We should use and promote mass transport system. If possible go on foot or use bicycle for short distances.

(11) We should not use materials containing CFC eg Refrigerators, Cups, etc.

(12) We should discourage the use of more fertilizers insecticides and pesticides but should encourage the use of bio fertilizers.

FLOOD

Floods have ravaged portions of India from time immemorial. Though floods are one of the very few well recorded natural phenomena, the catastrophic damages caused by them attracted focused attention in recent decades. With increasing population pressure and accelerated economic development, the adverse effects of floods are being increasingly felt now. Floods cause great distress whenever they damage crops and property and endanger lives. The term Flood is generally defined as a relatively high flow or stage in a river and the inundation of low land which might result therefrom. In a broader sense the term flood is used to convey all their outfalls into main rivers, outflow due to jamming or blocking of rivers by landslides and inadequate drainage to carry away surface water speedily. Coastal floodings are also covered.

In India vast stretches of land are submerged under water and other adverse effects are caused, such as destruction or damage to houses, property, bridges roads and other means of communication lives lost etc. year after year. The disastrous floods of 1954 and the immediate succeeding years resulted in the initiation of organized and coordinated flood management efforts to mitigate the problem.

CAUSAL PHENOMENA AND CHARACTERISTICS

Flood are natural phenomena characteristic of all rivers. As is known, the rainfall in India is largely dependant on the monsoons and cyclonic depressions. Most of the rainfall is received during the southwest monsoon season during which heavy spells of rain are often experienced in the catchment over the period of a few days at a time. It could therefore be said that high rainfall coupled with inadequate channel capacity leads to flooding. Choking of rivers beds by natural causes or artificial obstructions aggravate the problem.

Flood damages are the combined result of natural phenomena of the floods coupled with the human activity in the flood plains. The fertile river silt has promoted large-scale settlements and cultivation of lands near the riverbanks and adjacent areas or even in the river bed region. The social and economic activities of the people increase. While these activities are going on in one hand, on the other the river continue to experience varying magnitudes and intensities of floods which cause damages, sometimes in disastrous proportions. In a way flood damage is the price paid for the human occupation and exploitation of the flood plain of the river. Even single events could result in a heavy toll of death as also property loss.

As we noticed, the basic cause of flooding is the high rainfall. Apart from that, the size of the catchment also usually governs the character of the flooding. On large rivers with big basins, such as the Ganga or the Brahmaputra, the riverflow in the lower reaches is relatively slow to change; in contrast to this, flash floods, most commonly associated with small catchment lead to very high build up as also lowering. They record very little time between the start of the flood and the peak discharge. Coastal floods are associated with tropical cyclones, storms surges and tidal conditions.

The general characteristics of floods are generally on the lines discussed so far but it must be noted that floodings are the complex results of interaction off a number of connected phenomena and that the flooding characteristic of each river is different from another. They cannot be easily classified even in types or groups.

In this unit, our interest in floods and flooding is not in the scientific phenomenon as such but the damages and economic disruptions caused by them. If there would have been no occupation of the riverfront or economic activities nearby, high floods might come as also subside without mankind being affected or bothered much. We, however, are concerned with flood losses. Flood losses may be defined as the destruction or impairment, partial or complete, off the value of goods and services or of health, resulting from the action of flood waters and the silt and debris they carry.

India is one of the highly flood prone countries of the world. Flood damage statistics, compiled from reports from the State Governments indicate that on an average (based on data for 1953 1990) about eight million ha. on land are affected by floods in India, involving about thirty three million people. In a high flood year, the figures will be many times more. Our neighbour Bangladesh also suffers seriously from floods. The floods of 1988 which caused high losses in India also caused serious flood problems there, affecting 45 million people and crop damage on two million ha. of land.

VULNERABILITY

From the earlier days mankind has learnt to live with nature. As people settled in environs with fertile soils and by the side of waterfronts, for raising food or on strategic considerations such as trade, commerce, communication or defence, they also realized that these regions that sustained them are also disasterprone. They soon learnt that lessons and started taking precautions so as to reduce their risks. The evidence noted in the form of houses build by silt, on the banks of major rivers are of this nature. In course of time the population pressures increased and the vigilance of the people also slackened. Thus mankind's vulnerability started increasing.

An extreme natural phenomenon capable of causing disaster (leading to loss of lives or damage to property) is known as a natural hazard. The process of identifying the probability of occurence of a natural hazard of a given intensity at a specific location, based on an analysis of natural processes and site conditions is termed Hazard assessment. Vulnerability indicate the conditions (physical, socioeconomic/political) which increase the community's susceptibility to disaster or which adversely affect its ability to respond to events. It thus gives an idea of the expected degree of damage to a construction or an economic activity when exposed to a natural hazard of a given intensity. Risks are the probable losses in a given area or to an infrastructure system caused when the hazard materializes.

The type and degree of flooding is influenced by many factors. The principal factors can be classified to fall under three groups.

(1) climatological

(2) hydrological and environmental conditions

(3) local geomorphology off the flood plain

In addition, coastal flooding also depends on the coastal configuration and tidal conditions.

ADVERSE EFFECTS OF FLOODS

All over the world, and throughout history, natural disasters have imposed human suffering and extracted heavy toll of losses. Recent instances have revealed that it is not merely the developing countries that have so suffered. The loss in some of the highly developed Nations is mind boggling notwithstanding the high standards of construction and extensive protection measures that they had undertaken.

Apart from the casualties, injuries and disablement, many sections of the population get affected by the floods. Cropped area gets submerged, eroded and strewn with sand leading to loss of crop production and consequential disruptions. Many houses are destroyed completely; others are damaged. Damage and loss to public and private utilities and industrial disruptions occur. Breakdown of economic activities occurs with corresponding loss of wealth.

As we noted briefly earlier, the statistics of flood losses reported by the State Governments, compiled by the Central Water Commission for the period 1953 to 1990 shows that on an average eight million ha. of land are affected involving some thirty three million people. Over a hundred thousand heads of cattle and more than one thousand and five hundred people are lost. The average annual loss or damage to houses, public utilities and crops was Rs.940 Crores. The extent of damage varies from year to year. In years of high floods the loss is many times the average figure.

The statistics compiled suffer from one disabilities and many suggestions for better compilation of flood damages have been also offered. Moreover damage figures compiled by interested parties or even the Govt. for other purposes may not indicate the precise picture of losses. However the broad figures as indicated above serve the purpose of indicating the order of losses. In any case the exact assessment of the comprehensive loss to the economy of the Nation or to the individuals is a near impossible task.

PREPAREDNESS

Disaster preparedness could be defined as the detailed planning for the prompt and efficient response immediately as soon as the anticipated event materializes. This effort to be very comprehensive inclusive of public education and awareness compaign ahead, provisions for the issuance of timely warnings, development of orderly evacuation plans, and preparations for providing the evacuees with food, clothing and shelter on emergency basis. The moment the disaster strikes will also mark the start of the emergency response period. The immediate onsite responses are spontaneous actions of local residents but their effectiveness could be improved by advance training. The speed and efficiency of the community reaction to save lives and mitigate suffering and losses is determined by adequate planning, training and rehearsals.

In the context of floods, it is well known that floods damage human settlements, necessitate evacuation to safer areas, damage crops and disrupt farming, wash away infrastructure items like irrigation, communication etc. and make land unusable. Disaster preparedness should also deal with all these aspects and other connected matters.

The National Flood Commission (1980) set up by the Government of India made a comprehensive study of the flood management scene in India and had made many valuable recommendations or flood management including flood disaster and cyclone disaster mitigation steps needed. The Government of India and the various State Govts. are also engaged in identifying and implementing the many steps needed to be taken in different parts of India to take care of local conditions. These steps include those on flood disaster preparedness.

The United Nations General Assembly designated the decade of the 1990s as the International Decade for Natural Disaster Reduction. The various activities taken up under this programme have focused attention on the many disaster preparedness measures.

EARTHQUAKE

Earthquakes are considered to be one of the most dangerous and destructive natural hazards. The commencement of this phenomenon is usually sudden with little or no warning. It is not yet possible to predict earthquakes and to make preparation against damages and collapse of buildings and other man-made structures. Actually earthquake consists of a sudden shaking (vibrations) of ground caused by disturbances in the earth's crust. An earthquake generates a set of horizontal and vertical vibrations of the ground which are random in character.

Earthquakes may be defined as a natural phenomenon which tends to create panic due to the trembling vibrations of sudden undulation of a portion of earth's crust caused by splitting of a mass of rock (Tectonic) or by volcanic or other disturbances.

This unit provides a general discussion about earthquakes. For clear understanding, we will first explain the general characteristics of earthquakes. Besides this precursors: instrumental and non-instrumental and vulnerability of the different regions of the country will be discussed to analyse the impact and effect of earthquake. Lastly nature of damage caused by earthquakes will be briefly described.

GENERAL CHARACTERISTICS

Impact of Earthquakes is sudden with little or no warning. However, following a major Earthquake, the after-shocks may give warning of a further earthquake. On some occasions, an earthquake may be preceded by a less intense tremors or foreshocks.

- It is not yet possible to predict magnitude, time and place of occurrence of an earthquake.
- The onset is usually sudden.
- Earthquake prone areas are generally well identified and well known on the basis of geological features and past occurrences of earthquakes.
- Major effects arise mainly from ground movement and fracture or slippage of rocks underground. The obvious effects include damage (usually very severe) to buildings and infrastructures alongwith considerable casualties.
- On the average about 18000 people die each year due to this disaster throughout the world.
- About 200 large magnitude earthquake (M>6.0) occur in a decade.
- The world's earthquake problem seems to be increasing with the increased population. high rise buildings and crowded cities.

The exact spot underneath the surface of the earth at which earthquake originates is known as "focus" while the point lying vertically above the focus is defined as "epicenter" of the earthquake. The seismic shocks originating at a depth of about 50 km. or less below the surface are termed as shallow focus earthquakes; otherwise these are known as deep focus earthquakes.

The energy released from the focus, due to elastic rebound of rocks is transmitted in all directions in the form of Earth's crust leading to earthquakes.

The power (energy) of an earthquake is reckoned in terms of its "magnitude" which is measured on an open-ended Richter Scale from 1 to 9. But it is not a linear scale and not even, a logarithmic

scale. This will be clearly understood from the following Table 5.9 which gives the equivalence of earthquake magnitude (on Richter Scale) and energy released by the explosion of a certain mass of TNT which is the well known measure of explosive power in any blast.

Table 5.9

Magnitude of Earthquake(on Richter Scale)	*Approximate TNT Equivalent*
1.0	170 gms.
3.0	180 Kg
	(180×10^3 gm)
	5700 tonne
6.0 (like Latur, 1993)	
	(570×107 gm)
	28 700000 tonne
8.5 (like Assam 1897 & 1950)	
	(287×10^{11} gm)

From the above, it should be clear that the energy released by an earthquake (and hence the destruction) increases enormously as the magnitude on Richter Scale rises. Another way to appreciate the enormous destruction potential of an 8.5 magnitude earthquake is to know that the energy released is approximate equal to 10,000 Hiroshima type Atom Bombs.

The primary waves (or P-waves) are transmitted due to longitudinal vibrations set up within the earth. These waves have the velocity of the order of several kilometers per second and cause the preliminary tremors on the surface of the earth. These waves create an effect of horizontal pull and push and are also called pull and push waves.

The secondary (or S-waves) on the other hand are transmitted due to transverse vibrations. These are known as surface or slow waves. Even though the amplitude and size are small compared to other waves, these are the most destructive since they create vertical up and down movements in the ground surface as against horizontal oscillation due to longitudinal waves.

While the "magnitude" of an earthquake defines the energy released by the event the "intensity" of the earthquake will depend on the particular place where it is measured. Obviously the intensity will decrease as the distance from the epicenter increases.

Earthquakes are graded in two ways based upon the magnitude or intensity of an earthquake. The magnitude of earthquake is measured on the Richter Scale which has been explained above. It is calculated based on the amplitude of the waves generated by the earthquake.

The intensity is calculated for a particular location and is dependent on the distance of that location from the epicenter.

PRE-CURSORS INSTRUMENTAL AND NON-INSTRUMENTAL

We have already stated that it is not yet possible to predict earthquakes. However, sometimes there are some indication that would indicate that perhaps an earthquake would occur. Such indications are called "precursors". There could be either instrumental, i.e., those that are measured by instruments or non-instrumental, i.e. those which can only be perceived and not measured. Needless to say, the non-instrumental precursors are more subjective.

Some of the generally recognized precursors are listed below:

Table 5.10

Instrumental Precursors	*Non-Instrumental Precursors*
(a) Changes in Velocities of P & S Waves	(a) Sudden rise or fall of water level in wells and lakes in a Country like India. With numerous villages and each village with several wells, this precursor of rise fall of water level is easy to notice. Similarly, changes in water level in lakes can be observed.
(b) Fore-shocks & after shocks.	(b) Mud and sand shows up in surface waters.
(c) Statistical pattern of shocks.	(c) Changes in flows of natural springs.
(d) Uplift or subsidence of ground	(d) Increase in salinity of water.
(e) Changes in gravity	(e) Advance and retreat of seas.
(f) Faults, displacements in Earth	(f) Unusual behavior of animals.
(g) Tilt and strain of underground rock formations.	
(h) Changes in elective resistance of rocks	
(i) Changes in earth's magnetic field.	
(j) Emission of Radon Gas from the ground	
(k) Unusual sounds from inside earth	

VULNERABILITY

Disasters result from vulnerable societies being exposed to a hazard. There can be physical vulnerability, social vulnerability and economic vulnerability on account of an earthquake disaster.

Physical vulnerability relates to buildings, infrastructure and agriculture. The vulnerability of buildings is dependent on their sets, shape, materials used, construction techniques, maintenance and proximity of buildings to others. The weightage attached to each factor will vary according to the characteristics of the particular earthquake.

Infrastructure may be considered in three broad groups: transport systems (roads, railways. bridges, airports, port facilities): utilities (water, sewerage and electricity); telecommunications; dams and flood protection embarkments.

Vulnerability analysis is especially concerned with the risk faced by critical facilities (sometimes termed "life-lines") which are vital to the functioning of societies in disaster situations especially such as in case of earthquakes. These facilities include hospitals, dispensaries and emergency services. Special consideration is given also to protect heritage buildings of great cultural and historical importance.

Social Vulnerability

Records of past earthquake disasters suggest that the following groups of people are particularly at risk and require special attention:

- Single parent families:
- Women, particularly when pregnant or lactating.
- Mentally and physically handicapped people:
- Children; and
- The elderly.

Poor people are less concerned with infrequent hazards. If there are groups whose livelihoods are at risk, living or working in densely populated areas, with low perceptions of risk and without institutional support, the cumulative effect would be high social vulnerability.

ECONOMIC VULNERABILITY

It measures the risk of hazards causing losses to economic assets and processes. It focuses only valuating the direct loss potential (i.e. damage or destruction of physical and social infrastructure and its repair or replacement cost, as well as crop damage and losses to the means of production); indirect loss potential (i.e. the impact on cost production, employment, vital services and income-earning activities); and secondary effects (epidemics, inflation, income disparities and isolation of outlying areas). With the insights provided by economic vulnerability analysis, it is possible to estimate direct and indirect losses and to design ways and means to mitigate them in relation to the estimated costs of relief/recovery actions and mitigation measures required.

IMPACT AND EFFECTS

In general terms, typical impacts and effects of earthquake disasters tend to be :

- Loss of Life.
- Injury
- Damage to and destruction of property.
- Damage to and destruction of subsistence and cash crops.
- Disruption of production.
- Disruption of lifestyle.
- Loss of livelihood.
- Disruption to essential services.
- Damage to national infrastructure and disruption to administrative and organizational systems.
- National economic loss.
- Sociological and psychological after-effects.

The following problem areas need particular attention in case of Earthquake disasters:

- Severe and extensive damage, creating the need for urgent counter measures, especially search and rescue, and medical assistance.
- Difficulty of access and movement.
- Widespread loss of or damage to infrastructure, essential services and life support systems.
- Recovery requirements (i.e., restoration and rebuilding) may be very extensive and costly.
- Occurrence of earthquakes in areas where such events are rather rare may cause problems due to lack of public awareness.

NATURE OF DAMAGE

Damages due to earthquakes are the related terms and depends upon various factors listed below:

(a) Nature of earthquake.

(b) Geological and soil conditions

(c) Quality of construction.

(d) Sociological factors.

Essential services such as water-mains, drainage systems, and electrical transmission lines are seriously damaged. Broken water-main cause flooding of the area and leave no water for drinking

or for fire-fighting. The sparking of high tension over-head electric cables cause fires, setting ablaze whatever combustible material is in the vicinity. Leaks from cooking gas cylinders or supply lines also cause fires.

Disrupted drainage lines spread noxious fluids and give rise to diseases and epidemics.

Geological faults in the Earth's crust become activated and accentuate displacement of the ground, producing gaping fissures in which human beings and animals are known to have been engulfed. Telephone and telegraph poles fall down and the services go out of order. Communication are seriously hampered or altogether stopped. Railway lines are twisted out of shape and rail communication to and from the affected area is broken off. In some cases the only access to the affected area is by helicopter.

Large dams in the vicinity may be affected, and in some cases may even burst and cause floods. On the coast, huge wanes called tsunamis lash the shore and bring down houses and other structures and dislocate fishing and navigation.

In the Makran Coast Earthquake of 26th November, 1945, four new islands had come up through the huckling of two sea-floor. The islands were roughly circular in shape, 100 to 200 meters in diameter and rose to some 10 to 20 meters above the sea level.

Such creation of islands is a rare phenomenon but does occurs due to some earthquakes. They were composed of loose sand and clay and were being eroded fast due to waves and tides.

CYCLONE

Cyclones are one of the most disastrous natural hazards in the tropics and are responsible for deaths and destruction more than any other natural calamities. Cyclones bring with them extremely violent winds, heavy rain causing floods and storm tides causing coastal inundation.

Cyclones form over the warm ocean waters (sea surface temperature of the order of 26°C or 27°C) little away from the equator within the belt of 30°N and 30°S. In our area, cyclones form in the Bay of Bengal and the Arabian sea. As they move westward or northwestward, those forming in the Bay of Bengal come to the Indian territory while those forming in the Arabian Sea generally go away from India but sometimes they turn around to hit Gujarat.

CHARACTERISTICS

Tropical cyclones are large, rotating, atmospheric, phenomena extending horizontally from 150-1000 Km and vertically from surface to 12-14 Km. These are intense low pressure areas with a spiral shape. Fierce winds spiraling anti-clockwise in the northern hemisphere blow around the cyclone centre. Cyclones generally move 300-500 Km in 24 hours over the ocean. The severest category of cyclones have wind speeds of 115 kmph or more and are classified as Severe Cyclonic Storm with a core of Hurricane winds.

Cyclones develop from areas of low atmospheric pressure and go through the stages of depression and deep depression before attaining the category of cyclone. Each category is recognized on the basis of windspeed as indicated below:

Table 5.11

Categories	Wind Speed
1. Low Pressure Area	<30 kmph
2. Depression	30 to 55 kmph
3. Deep Depression	55-65 kmph
4. Cyclonic Storm	66-90 kmph
5. Severe Cyclonic Storm	90-115 kmph
6. Severe Cyclonic Storm with a core of Hurricane wind	>115 kmph

A well developed cyclone consists of a central region of light winds known as its "Eye". The eye has average radius of about 20 to 30 km, but it can be 40 to 50 km in large cyclones. The eye is an almost cloud-free zone and it is surrounded by a ring of very strong winds extending on an average up to 30 to 50 km beyond the centre. This area is known as zone of maximum wind. Surrounding this region, winds spiral in the counterclockwise direction in the northern hemisphere, extend outward to large distances, with speeds gradually decreasing as one moves further away from the centre.

On an average, about 5-6 cyclones form in the Bay of Bengal and the Arabian Sea every year, out of which 2-3 may be severe. More cyclones form in the Bay of Bengal than in the Arabian Sea. The ratio is 4:1. Tropical cyclones in these seas generally form between 5°N and 20°N. There are two distinct seasons of cyclones in our area. One is from May to June (Pre-monsoon) and the other is from October to mid-December (Post-monsoon). May, June, October and November are known for severe cyclonic storms.

Almost the entire east coast is vulnerable to cyclones with varying frequency and intensity. In the west coast, the North West coast (coast north of Mumbai) is more vulnerable as compared to southwest coast (South of Mumbai).

WARNINGS

Cyclone warnings are provided through six cyclone warning centres located at Calcutta, Bhubaneswar, Visakhapatnam, Madras, Bombay and Ahmedabad. These centres have their distinct area wise responsibilities covering both the east and west coasts of India and the oceanic areas of the Bay of Bengal and the Arabian Sea, including Andaman and Nicobar and Lakshadweep. Cyclone warnings are issued to the All India Radio (AIR) and the Doordarshan for broadcast/telecast in different languages. Cyclone warnings are also given to control room and Crisis Management Group in the Ministry of Agriculture, Government of India, who are finally responsible for coordinating various activities of Centre and Government and other agencies in respect of cyclone warnings.

Cyclones are tracked with the help of INSAT, powerful cyclone detection radars and conventional meteorological observations including weather reports from ships. At present cyclone detection radars are installed at (i) Calcutta, (ii) Paradip, (iii) Visakhapatnam, (iv) Machhlipatnam, (v) Chennai, (vi) Karaikal on the east coast; and (vii) Goa, (viii) Cochin, (ix) Mumbai and (x) Bhuj along the west coast. Present cyclone surveillance system in India is such that no cyclone in the region will go undetected at any time of its life cycle.

The important components of cyclone warnings are the forecast of future path and intensity of a cyclone and the associated hazardous weather. For the preparation of future position (path) of tropical cyclones and for estimation of storm surges, modern computer based techniques are used in addition to conventional methods. Intensity forecasts are made by using satellite techniques.

Cyclone warnings are provided in two stages. In its first stage, a "Cyclone Alert" is issued 48 hours before the anticipated time of commencement of adverse weather along the coast in the 2nd stage, a "Cyclone Warning" is issued 24 hours before the cyclone's anticipated landfall warnings for the ports and fisheries start much earlier. Ports are warned day and night through a specially designed port warning system. Informatory messages on cyclone are issued to All India Radio and Doordarshan much earlier, as soon as a tropical cyclone is detected in the Bay of Bengal or in the Arabian Sea.

Cyclone warnings are disseminated through the following means:

- Telegrams with highest priority
- Telecast through Doordarshan
- Broadcast through AIR

- Bulletins to the press
- Broadcast through Department of Telecommunications, Coastal Radio Stations for ships in the high seas and coastal areas, and
- INSAT based Disaster Warning System.

In addition to above, cyclone warnings are disseminated through teleprinters, telex, facsimile and telephones wherever such facilities exist with the recipients.

PREPAREDNESS

The preparedness means measures which enable government organizations, communities and individuals to respond rapidly and effectively to disaster situations. The preparedness measures include the formulation of viable disaster mitigation plans.

The preparedness actions have to be planned ahead of disaster. It would consist of a plan of action to be implemented on the receipt of the Cyclone Alert message from Cyclone Warning Centre. A cyclone alert is issued generally 48 hours before the possibility of the area being affected by strong winds, heavy rain and storm surges. The Action Plan would indicate how evacuation of people would be effected and the places where they could be evacuated to. The identification of strong buildings which would withstand the fury of the storm is an important segment of preparedness action plan. The safe storage of non-perishable food and other essential needs, adequate collection of stocks of drinking water and medicines, have to be made. Most of the maritime states have prepared Cyclone Disaster Preparedness handbooks or manuals, where action plans of various organizations have been indicated in the case of cyclone threat. It is desirable that as an essential component of preparedness, the action points indicated in the manuals are rehearsed at the beginning of the cyclone season.

To deal with cyclone situation a contingency plan has been evolved by the Ministry of Agriculture, who is the nodal agency at the Centre to co-ordinate the activities of various Central departments and the affected State/States to cope up with the natural disaster in general.

Training programmes for the disaster management officials and Non-Government Organisations (NGOs) are arranged by several management and public institutions in India.

RISK REDUCTION PROCESSES

The prevention of tropical cyclone formation is not within the realm of possibility. However, the loss of human lives and destruction of properties can be minimized by adopting prescribed short and long term measures for risk reduction. While cyclone warning system is the most important constituent of short term risk reduction measures against cyclone disaster, the risk assessment of tropical cyclone falls under long term measures.

As prevention of formation of tropical cyclone is not in the realm of possibility, some structural and non-structural preventive measures of long term nature can be undertaken to mitigate the suffering of cyclone affected people. Structural measures like construction of cyclone shelters, embankments, dykes, reservoirs and coastal afforestation are some of the long-term risk reduction measures for cyclone disasters. Creation of proper awareness, training and education of people in the vulnerable communities, introduction of insurance can be some of the non-structural measures.

EFFECTS

Severe tropical cyclones are responsible for large casualties and considerable damage to property and agricultural crop. The destruction is confined in the coastal districts and the maximum destruction being within 100 km from the centre of the cyclones and on the right side of the storm track. Principal dangers from a cyclones are: (i) very strong winds, (ii) torrential rain, and (iii) high storm tides. Most casualties are caused by coastal inundation by storm tides. Maximum penetration of storm surges varies from 10 to 20 km inland from the coast. Heavy rainfall and floods come nest

in order of devastation. They are often responsible for much loss of life and damage to property. Death and destruction directly due to winds are relatively less. The collapse of buildings, falling trees, flying debris, electrocution, aircraft accidents and disease from contaminated food and water in the post-cyclone period also contribute to loss of life and destruction of property.

Floods generated by cyclone rainfall are more destructive than winds. The rainfall is the heaviest around wall cloud zones. Rainfall of the order of 20 or 30 cm per day is very common.

Tropical cyclone's worst killer comes from the ocean, viz., the storm surge. Over the deep oceans wave generated hurricane force winds may reach height of 50 feet or more. Below the storm centre, the ocean surface is drawn upward by 30 cms or so above normal due to the reduced atmospheric pressure in the centre. As the storm crosses the continental shelf and moves coastward, the mean water level increases. This abnormal rise in sea level caused by cyclone is known as storm surge. The surge is generated due to interaction of air, sea and land. The cyclone provides the driving force in the form of very high horizontal atmosphere pressure gradient and very strong surface winds. As a result the sea level rises and continues to rise as cyclone moves over shallower water, and reaches a maximum on the coast near the point of landfall (Point of crossing coast). Surge is maximum in the right forward sector of the cyclone and about 50-100 km from the centre coinciding with the zone of maximum wind. Winds in this sector is from ocean to land.

Due to significant improvement in cyclone warning system and adequate and timely steps taken by the government and other agencies, the loss of human lives is in the decreasing trend, although, loss of properties shows an increasing trend. The increase in the loss of properties is due to increased activity but unplanned human activities and non-engineered construction along the coast also contribute to the damage suffered by property. In support of the above statements we present some data on recent cyclones in the table 5.12 below. It may be seen that although the November 1977 and May 1990 cyclones, which occurred in the same coastal area of Andhra Pradesh and had the peak wind speeds of the same order, yet the loss of human lives in the case of the 1990 cyclone was much less in comparison to that of 1977 cyclone but the economic losses were many times more in the 1990 cyclone.

Table-5.12

Cyclone	*Peak(m/Sec)*	*Human Loss*	*Loss of (Millions Rupees)*	*Month/year*
Chirala	70	10.000	3500	Of November 1977
Machhlipatnam	58	700	1700	Cyclone of May 1979
Sriharikota	58	604	4000	Cyclone of November 1984
Machhlipatnam	65	967	22.480	Cyclone of May 1990

LANDSLIDES

Often it is not realized that a large part of India consists of mountainous terrain. In the north, there is the extensive Himalayan mountain system extending all along from the west to the east. Its lofty peaks rise to more than 8000 metres height. The middle ranges of the Himalayas are about 5000 metres high on the average while the foothills rise to about 6000 metres. The Himalayas abound in glaciers and are the origin of many rivers and streams. There is abundant rainfall and snowfall often accompanied by strong winds.

The peninsular region of India starts from the Vindhyachal ranges and consists of the Deccan Plateau which slopes eastwards. On its edges, this great plateau is bound by the mountain ranges of the Eastern Ghats and the Western Ghats. The Nilgiri mountains are in the southern parts of the plateau. The west-central parts of the country have the ranges of the Aravali mountains.

Many of these mountains systems are relatively new (in the geological sense) and are still growing such as the Himalayas. The rock systems are therefore fragile.

Given these special geological and geographical features and combined with the heavy rainfall system of the two monsoons (the summer monsoon and the winter monsoon) and also the not so rare occurrence of earthquakes, it is but natural that the mountainous areas of India are vulnerable to the hazards of landslides. In the snowy regions of the Himalayas, snow avlanches are the additional dreaded disasters.

LANDSLIDES IN INDIA

Landslides affect the remotely located, often isolated, small communities in villages or hamlets in the mountain regions of the country where external assistance takes time to reach in times of emergency when the normally difficult terrain and tracks may become almost impossible to negotiate. Many a times, even the information about the occurrence of such events and the damage done takes days to reach the district and state headquarters. Because of these reasons, landslides and snow avalanches assume the status of major natural disasters even though the affected area and population may be rather small.

Areas Struck with Frequency and Intensity

Landslides are a frequency and recurring phenomenon in the various hill ranges of India from Kerala to the Himalayas. Areas prone to landslides also include the Eastern and Western Ghats, the Nilgiris, the Vindhyachals, the mountains in the northeastern States and the great Himalayan range. The incidence of landslides in these regions is a recurring feature especially during and after spells of heavy rains. As the geological history of the rocks and the rainfall regime have strong bearing on the incidence of landslides, there are variations in the occurrence of landslides in different parts of the country as is indicated in Table 5.13 given below.

Table 5.13 : Incidence of landslides in India

Region	*Incidence of Landslides*
Himalayas	High to very high
Northeastern Hills	High
Western Ghats and the Nilgiris	Moderate to high
Eastern Ghats	Low
Vindhyachals	Low

Kind and Magnitude of Damage

There is no doubt that anything that comes in the ways of a landslide will suffer severe damage and may even by totally buried or wiped out. Anything located on top of a landslide will also not survive when the rock or mud slips out from below it.

Landslides : More often, the major landslides are combinations of rockslide and rockfall. They all involve movement or mass (soil, debris or rock). The process of movement of mass may vary from slow soil creep to abrupt and sudden rockfall. Landslides, also known as landslips, range from low angle and rather slow slides to sudden vertical falls.

Based on the type of movement, relative rate of movement and kind of material involved, landslides can be designated into 5 kinds as follows:

- Slump with earthflow
- Debris slide
- Debris fall

- Rock slide
- Rock fall

Landslides, being more widespread in different mountainous or hilly regions of the country (as against snow avalanches which are confined to the snowy of the Himalayas), cause damage which is more varied and more widespread. Increased population, spurt in quarrying, mining and construction activities near unstable hill slopes, ill conceived developmental activities in the vulnerable hilly areas, have resulted in more landslides and greater damages. Apart from the catastrophic damages suffered by communities living on or near unstable hill slopes as their houses along with persons and property may be destroyed by a landslide, the most crippling damages due to landslides are suffered by (i) roads and (ii) productive soil. Damage to roads leads to considerable inconvenience and economic loss. The disappearance land and the cultivable top soil takes away the agricultural potential of the affected area thus depriving them of their already livelihood seriously.

Landslides are also known to result in blocking of streams or overflowing of lakes thus causing flash floods because large volumes of debris falling in a lake or reservoir cause its water to overflow or the temporarily blocked stream may suddenly release the huge quantity of impounded water to cause a devastating flash flood downstream.

Relief and Rehabilitation

Essentially, the relief steps comprise the following:

(1) Search and Rescue
(2) Medical assistance to the injured
(3) Disposal of the dead
(4) Food and water
(5) Emergency shelter for the homeless
(6) Opening up access roads if blocked; and restoration of communication channels
(7) Psychological counseling of the survivors who have lost their close relatives
(8) Repair of houses and facilities
(9) Assistance (technical and financial) to restart economic activity to restore regular work and income
(10) Reconstruction through proper planning.

Measures for the rehabilitation of a community affected by landslide or snow avalanche will depend very much on the extent of the damage done by the disastrous event.

If the damage has not been severe, the rehabilitation will take the form of (a) short-term relief to restart life and (b) taking long-term measures so that any future landslide or snow available does not hurt the community at all or at least, not as much.

We have already discussed the relief steps in the preceding section . As regards the long-term measures, these will comprise the following:

(1) Reducing the hazard proneness of the site through engineering measures such as strengthening or modifying the slopes, removing fragile and unstable portions, securing snow accumulations by snow fences, snow nets or by cribbing, and improvement of drainage.
(2) Stopping indiscriminate quarrying and mining in mountain areas.
(3) Afforestation of zones prone to landslides so that trees and vegetation provide a binding force to prevent slippage of debris, rock, and snow.

(4) Creation of a voluntary, community based preparedness system of watch, monitoring and alert. This will not only be useful in times of a disaster but will provide enough self confidence (and thereby self reliance) which is an essential objective of an effective rehabilitation programme.

(5) Provision of assistance for economic rehabilitation by arranging work, employment loans, and grants.

In the extreme case of severe damage to a community by a landslide or snow avalanche, the site may be rendered totally unusable. In that case, rehabilitation takes the form of relocation and reconstruction. In such an event, the new site should be carefully chosen so as to minimize vulnerability and risks.

Social Issues and the Environment

Undoubtedly man is related with environment and he is solely dependent on nature. But since few years, over exploitation of natural resources disturbed the environment. Environment effects our life style, culture, social components etc. Technological development also have great impacts on social and natural resources. Development does not mean the increase in GNP(Gross National Product) but it should be visualized in a holistic manner, where it brings benefits to all. Though the natural environment undergoes continual change but man also produced some changes like domestification of animals, introduction of agriculture, development of industries etc. Increased population and higher consumption per head greatly effects the environment. The success of environmentally sound development depends on proper understanding of social needs, opportunities and of environmental characteristics

FROM UNSUSTAINABLE TO SUSTAINABLE DEVELOPMENT

More and more natural resources were consumed in the process of satisfying the rapidly growing needs of the habitat. Every development activity has some impact on the environment. For meeting the needs, the human can not live without the developmental activities. Consequently, there is need to harmonize developmental activities in such a way that environment should not polluted at least. Unsustainable development means the development of a few privileged nations both in science and technology. Such developments are at the cost of our life supporting systems like air, water, soil and over exploitation of our natural resources which may lead to the collapse of the inter- related systems of the earth. If growth continues in the same way, very soon we will be facing a "doom's day".(Meadow et al 1972)

To be sustainable, development must process both economical and ecological sustainability. The concept of sustainable, development has received much recognition after the Stockholm Declaration 1972. The Brundtland (1987) has defined that sustainable development is development that meets the needs of the present without compromising the ability of the future generations to meet their own needs. The earth summit held at Rio-de-Janeiro in 1992 put the world on the path of sustainable development which aim at meeting the needs of the present without compromising the ability of future generations to meet their own needs. The Rio declaration has taken cognizance of the fact that in order to achieve sustainable development, eradication of poverty is indispensable and thus development process and environment protection must go on simultaneously.

Freedom and sustainable development are mutually exclusive ideas. Freedom encourages people to do what they want to do, sustainable development dictates what people may and may not do. Freedom empowers people to control Govt., sustainable development empowers Govt. to control people.

There are two aspects of sustainable development :-

(i) *Inter-generational equity* – This emphasizes that we should stop over-exploitation of resources, reduce waste discharge and emissions and maintaining an ecological balance. It expects to hand over a safe healthy and resourceful environment to the future generations.

(ii) *Intra–generational equity* – This emphasizes that technological development should support economic growth of the poor countries so as to reduce the weather gas within and between the nations.

Measures for sustainable development – There are following major measures for sustainable development:-

1. *To promote environmental education and awareness* – From childhood, we should develop a feeling of belongingness to earth. This can be possible by introducing environment as a subject in education from primary stage. Media can also be helpful in developing such feelings. The transformations of policy making process from one that reflects and is controlled by the will of the people, to a process controlled by the selected elite who have found ways so impose policies fashioned by the international community to achieve what they believe to be sustainable development.
2. *Three 'R' approach* – Three 'R' means, Reduce, Reuse and Recycle. We should reduce the excessive use of natural resources, but use them again and again instead of passing it on to the waste stream. Recycle the materials to reduce pressure on our existing natural resources.
3. *Appropriate technology* – The technology should use less resources and produce minimum waste. It is over which locally adaptable, eco friendly, resource efficient and culturally suitable.
4. *To utilize resources as per carrying capacity of the environment* – Sustainability of a system depends largely upon the carrying capacity of the system. If carrying capacity of a system crossed, environmental degradation status and continues till it reaches a point of no return. Carrying capacity has two basic components-
   (i) *Supporting Capacity* – It is formed of productive and protective systems.
   (ii) *Assimilative Capacity* – It is formed of the systems which utilize the wastes produced by human activities.

The key to sustainable growth is not to less but to produce differently, offering solutions to a broad range of environmental problems. To achieve sustainability, economic growth can not be based on over exploitation of the resources but must be managed to enhance the resource base.

Urban Problem Related to Energy

Urban areas are developing very fast. In most of cities there is influx of populations from surrounding areas, mostly in search of employment and better living conditions. Therefore, it is difficult to accommodate all the industrial, commercial and residential facilities within limit. As a result, cities are spreading in to sub-urban or to rural areas. Uncontrolled population, irregular development are the main factor for receding facilities in urban areas. Energy is required in every walk of life like industry, transport, defence, agriculture, trade, education, domestic etc. Cities are the main centers of economic growth. Hence, energy is the most important input for development. The energy requirements of urban population are much higher than that of rural ones. Energy

problems become more severe due to the limited amount of non-renewable resources of energy. Rapid utilization of fossil fuels produces increased production of wastes which causes environmental pollution. Energy problem day by day becoming serious. People are facing for 'power cut'. Energy demand is higher than production. There are following main causes of energy problems.

1. Increasing use of energy for domestic and commercial purposes (due to increased population and industrialization).
2. Industrial plants using big proportion of energy.
3. Non renewable resources of energy like coal, petroleum and natural gas are decreasing.
4. Increasing of transport means.
5. Decreasing production of Hydro electricity due to insufficient rains.
6. Transmission loss due to defected power distribution system.

There are following steps to solve the energy related problems.

1. To control urbanization.
2. To develop renewable resources of energy like solar radiation, wind power, hydel power, nuclear power, bio mass etc. These are pollution free also.
3. Non renewable energy resources should be used only when no non-conventional source of energy is available.
4. Welcoming the awareness programs to save energy.
5. Effective measures for transition loss and energy theft.

WATER CONSERVATION

Water is needed in almost every sphere of human activity. Without water life is not possible. In many aspects the properties of water are unique. It is called universal solvent. No other liquid can replace it. The global distribution of fresh water on earth's crust including ground water and water present as its vapours in atmosphere.

Table 5.1 Global distribution of fresh water

	Water in Cubic KMS
1. Water in snow caps, Ice sheets, Glaciers etc.	24,000,000
2. Surface ponds, Lakes and reservoirs	280,000
3. Water in Streams and rivers	1,200
4. Water present as soil moisture	85,000
5. Ground Water	60,000,000
Total amount of fresh water on our planet	84,366,200

Water is required for direct consumption or indirectly for washing, cleaning, cooling, transportation or even for waste disposal. Important sectors of human activity, which require water can be grouped as:-

1. Irrigation
2. Industries
3. Live stock management
4. Thermal power generation
5. Domestic requirements
6. Hydroelectric generation, fisheries navigation and recreational activities.

According to 1970 survey, about 3500 cubic kms of water are drawn for human use every year. Agriculture sector is the biggest consumer of fresh water. The amount of water drawn for human use is never used up completely. A large fraction is returned to the surface deposits or stream flows often in a polluted state. Water requirements have greatly increased due to rapid

population growth, industrialization and agriculture. The demand for water is likely to exceed its supply by the first or second decade of the next country. The shortage of water shall make many localities barren, devoid of life. Fertile land become deserts. Conservation of water is, therefore an absolute necessity of today. Otherwise the tomorrow will be grion, drier and barren to live through. The following steps should be taken for conservation of water.

1. *Water economy, Re-use and Recycling.* If water meters are installed and charged properly, the consumption of water in domestic establishments, livestock management and industries shall drastically decline. The heated water from thermal power plants, where large amount of water is needed, may be utilized elsewhere after proper cooling. The same is true for many industries, water used once may be used again for another purposes.

2. *Agricultural runoffs from fields.* This can be used to irrigate cropland down the stream, while an efficient use of water with conditions of proper drainage can significantly reduce the agricultural runoffs.

3. *Efficient distribution system.* Water resources are not distributed evenly. Some localities have plenty of water and others have little. Many river basins have plenty of water, which flows down un-used to the sea. Surplus of one basin can be used to make up the deficit at another.

4. *Enhancement of surface storage capacity.* About 27000 Cubic kms of fresh water which rush down to the oceans through stream and rivers are of no use to the mankind. We can store this water in tanks, reservoirs, dams for further use in drier seasons.

5. *Reduce evaporation losses.* Water losses through evaporation and seepage are enormous both from the reservoirs and distribution system. It should be reduced.

6. *Improvement of underground storage capacity.* The fresh water is stored in underground deposits. Every year about 10-15 % of the total precipitation enters the ground water table. These deposits regularly feed streams and rivers during the drier periods. These deposits are cheap and easily obtainable.

7. *Desalination of Sea Water.* A huge store of water exists in our oceans. If the salt content of the sea water is removed, we can use it. This can be done by desalination plants.

8. Afforestation and Reforestation of hill slopes to check loss of water in floods.

9. Artificial rain making and precaution of water pollution.

RAINWATER HARVESTING

Water is an essential natural resource for sustaining life and environment. The available water resources are under tremendous pressure due to the increased demands and time is not far when water, which we have always thought to be available in abundance and free gift of nature, will become a scarce commodity. Conservation and preservation of water resources are urgently required to be done. Water management has always been practiced in our communities since ancient times, but today this has to be done on priority basis. The ministry of Water resources in India is endeavoring to make **rain water harvesting** a part of every day life in our villages and cities as a people's movement, and this will go a long way in the management of ground water as a sustainable resource.

While we have taken impressive strides in advance management of water resources, we also need to learn from the wisdom bestowed by our forefathers. One such wisdom is the concept of rain water harvesting. It is high time that the Government and the people join hands for creating awareness of the importance of rain water harvesting with the main objective of adopting these measures and techniques throughout the country. A judicious mix of ancient knowledge, a modem technology, public and private investment, and above all, people's participation will go a long way in reviving and strengthening water- harvesting practices throughout the nation.

Rainwater harvesting is control or utilization of rainwater close to the point rain reaches earth. It is categorized into domestic rain water harvesting and rain water harvesting for agriculture, erosion control, flood control and aquifer replenishment.

Domestic rain water harvesting, also known as roof water harvesting or roof top rain water harvesting is the technique through which rain water is captured from roof catchments and stored in tanks or reservoirs.

Rain water harvesting systems, both small and large, consists of six basic components.

(a) Catchment area/roof, the surface upon which rain falls.

(b) Gutters and downspouts, the transport channels from catchment surface to storage.

(c) Leaf screens and roof washers, which are systems that remove contaminants and debris.

(d) Cisterns or storages tanks, where rain water is stored.

(e) Water treatment, the filters and equipment as well as additives to settle, filter and disinfect.

The system involves collecting water that falls on zinc, asbestos or tile roof of house during rein storms and conveying it by an aluminum, PVC, wood or plastic drain or collector to a nearby covered storage unit. The rain water yield varies with the size and texture of the catchment area. A smoother, cleaner and more impervious roofing material contributes to better water quality and greater quantity. The most common container now a days is a metal drum or barrel with a capacity of about 200 liters, set up at the foot of the fall pipe. This is enough to supply a family for 5 to 7 days with 6 liters per person per day, with possibility of using more than one storage barrel.

It is interesting to note that annually replenishable resources are assessed as 432 billion cubic meters(BCM) and by adopting water harvesting, an additional 160 BCM shall be available for use. The ground water levels in some areas are falling at the rate of one metre per year and rising in some other areas at the same rate. ***The main causes of fall in ground water levels are:***

(*a*) Overexploitation or excessive pumping either locally or over large areas to meet increasing water demands.

(*b*) Non-availability of other sources of water. Therefore, sole dependence is on ground water.

(*c*) Unreliability of municipal water supplies both in terms of quality and quantity, driving people to their own sources.

(*d*) Misuse of ancient means of water conservation like village ponds, baolis, percolation tanks and therefore, higher pressure of ground water development.

The main effects of overexploitation of ground water resources are:

(*a*) Drastic fall in ground water levels in some areas.

(*b*) Drying up of the wells/bore wells.

(*c*) Enhanced use of energy.

(*d*) Deterioration in ground water quality.

(*e*) Ingress of sea water in coastal areas.

You can capture and recharge 65,000 litres of rain water in Delhi from a 100 Sq. m. size roof top and meet drinking and domestic water requirements of a family of four for 160 days. *The* ***method and technique include:***

(*a*) Roof top rain water harvesting and its recharge to underground through existing wells or bore wells or by constructing new wells, bore wells, shafts, spreading basins, storm water drains etc.

(*b*) Harnesting runoff in the catchments by constructing structures such as gabions, checkdams, bhandaras, percolation trenches, sub-surface dykes etc.

(*c*) Impounding surplus runoff in the village catchment and water sheds in village ponds and percolation tanks.

(*d*) Recharging treated urban and industrial effluents underground by using it for direct irrigation or through recharge ponds or wells etc.

The main objectives of rain water harvesting are :

(*a*) To restore supplies from the aquifers depleted due to over exploitation.

(*b*) To improve supplies from aquifers lacking adequate recharge.

(*c*) To store excess water for use at subsequent times.

(*d*) To improve physical and chemical quality of ground water.

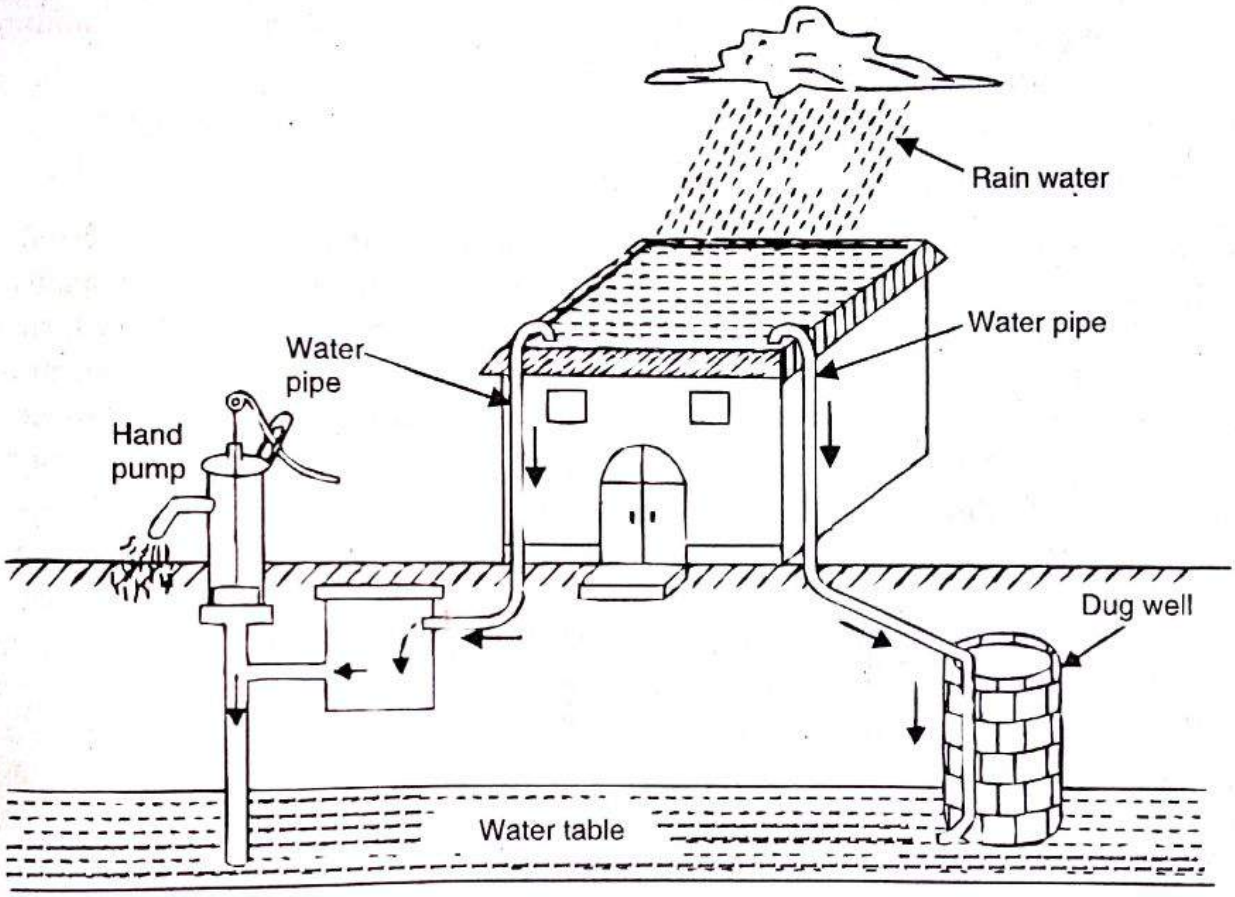


Fig. 6.1. Roof-top rainwater harvesting by recharging (*i*) through hand pump or (*ii*) through abondoned dugwell.

(*e*) To reduce storm water run off and soil erosion.

(*f*) To prevent salinity ingress in coastal areas.

(*g*) To increase hydrostatic pressure to prevent or stop land subsidence.

(*h*) To recycle urban and industrial waste waters etc.

(*i*) To rehabilitate the existing traditional water harvesting structures like village ponds, percolation tanks, baolis, tanks etc.

(*j*) To convert the traditional water harvesting structures into ground water recharge facilities with minor scientific modifications and redesigning.

(*k*) To use the existing defunct wells and bore wells after cleaning and also the operational wells as recharge structures.

The expected advantages of rain water harvesting are :

(*a*) Rise in ground water levels in wells.

(*b*) Increased availability of water from wells.

(c) To prevent decline in water levels.

(d) Reduction in the use of energy for pumping water and consequently the costs. One metre of water level saves about 0.40 kwh assuming 10 hours of pumping per day for 365 days.

(e) Reduction in flood hazards and soil erosion.

(f) Improvement in water quality.

(g) Arresting sea water ingress.

(h) Assuring sustainability of the ground water abstraction sources and consequently the village and town water supply systems.

(i) Mitigating the effects of droughts and achieving drought proofing.

(j) Reviving the dying traditional water harvesting structures and their rehabilitation as recharge structures.

(k) Effective use of lakhs of defunct wells and tube wells as recharge structures.

(l) Upgrading the social and environmental status etc.

Rain water harvesting essentially means collecting rain water on the roof of buildings and storing it underground for later use. Not only rain water harvesting increases water availability, it also checks the declining water table. Every drop of water has to be saved and this will ensure that water is not wasted. Moreover, rain water harvesting is not only simple but economical too. The process of rain water harvesting is environmental friendly, helps improve ground water quality, helps to meet increasing demand for water, particularly in urban areas and prevent flooding of roads.

In **Madhya Pradesh,** more than 1000 check dams, 1050 tanks and 1100 community lift irrigation schemes have been implemented in Jhabua district. The result-drought proofing achieved and food production increased by 38% in the past 5 years. Moreover, micro-watershed project with people's participation in Ghelhar Choti village, Jhabua district has been implemented. The result is that cultivated areas increased and yield per hectare doubled. Low cost small farm reservoirs along with improved crop and soil management systems tried in Chhattisgarh region of Madhya Pradesh and it augmented ground water storage, saved paddy from water stress during extended dry spells in 1990-91 and 1991-92. District administration in Dewas made roof top rain water harvesting mandatory for all houses having tube wells and banned tube well drilling. This resulted in improved soil moisture and recharged first-aquifer. This technique is also popular in other states like Maharashtra, Rajasthan, Andhra Pradesh etc.

WATERSHED MANAGEMENT

Watershed is a drainage area on earth's surface from which runoff, resulting from precipitation flows past a single point in to a large stream, a river, a lake or the ocean. It is a geo-hydrological unit and drains at a common point, has been accepted world over as a scientific unit for development. The watershed can range from a few square kilometer to few thousand square kilometer in size. Damodar Valley Corporation in 1949 adopted first Integrated Watershed Management. Watershed development is the rational utilization of natural resources of soil water and vegetation for increasing and stabilizing the productivity of land on a sustainable basis. The development of watershed will result in increase in sub soil water regime, recharge of wells. The watershed based development approach is undoubtedly an agreeable concept to set the goal. But this demands a massive people's movement to make the village community self reliant.

The watersheds are very often found to be degraded due to uncontrolled, unplanned and unscientific land use activities like over grazing, deforestation, mining, soil erosion, industrialization etc.

Objectives of watershed management. Watershed management is the rational use of land and water resources for optimum production causing minimum damage to the resources. The main objectives of watershed management are as :-

1. To increase agricultural production i.e. increasing the availability of fodder, fuelwood, timber and raw materials for industries.
2. The rational utilization of natural resources like water soil and vegetation.
3. To minimize the risks of floods, droughts and landslide.
4. To Manage the watershed for developmental activities like domestic water supply, irrigation, hydropower generation.
5. To develop the rural areas and their lifestyle.

Under the development of national policy, the watershed management was included in fifth Five Year Plan. Now a days, a number of national watershed development programmes are in progress. Various measures are necessary for watershed management. Some of them are :-

1. Scientific mining and quarrying must be done in the watershed areas because hills loose stability and get disturbed by improper mining.
2. Water harvesting in the watersheds to be used in dry season in low rainfall areas.
3. Afforestation and agro forestry(crop plantation) should be promoted to prevent runoffs loss and soil erosion and increase soil moisture. Woody trees like Eucalyptus and Lencaena should be grown in between crops to reduce the runoffs and loss of fertile soil in high rainfall areas.
4. some mechanical measures like terracing, bunding, bench terracing, contour cropping etc. are used to minimize runoff and soil erosion in the slopy regions of watersheds.
5. To promote soil binding plants like Vitex.
6. People's participation should be ensured including farmers and tribals in the water shed management programmes. This can be done by properly educating people about the campaign or paying some incentives.

The Himalayas are one of the most critical watersheds in the world. Most of the watersheds of our country lie in this region. Successful watershed management has done at Sukhomajri and Panchkula with the active participation of the local people.

Resettlement and rehabilitation of people: Its problems and concerns

Some times for the development of projects like construction of dams, mining, creation of parks etc. and during natural calamities like Earthquake, Landslides, Volcanos, Floods, Droughts, Cyclones, the problems of resettlement and rehabilitation arise. For example recently the Tsunami cyclone affected thousands of families and during construction of Indira Sagar dam in Khandawa district of Madhya Pradesh thousands families were displaced and rehabilitated near Chhanera and other places. This caused permanent loss of the benefits and facilities. This disturbed Socio-economic and ecological base of local community which are generally forest and tribal people. Families are disintegrated and also lost ancestral link between people and the environment. This can easily be seen in old HARSUD where people still go to remember old environment. More than 13000 families are displaced during Tehri dam construction. They rehabilitated in Dehradoon and Haridwar regions. Various types of projects result in the displacement of native people are :-

1. *Displacement due to Dams.* Universe without energy is not imaginable. The most easily accessible and eco-friendly form of renewable energy is hydropower. Water is scarce natural resource and India is blessed with it. Hence it has to judiciously harnessed and managed for welfare of all living beings. India's exploitable hydropower potential is 84044 MW. River Narmada has 3000 MW hydropower potential in the state of Madhya Pradesh. Sardar Sarovar Project (Gujarat),

Hirakund (Orissa), Bhakra Nangal Dam (Punjab) Tehri Dam (Uttaranchal), Indira Sagar project (MP) etc. are some which displaced more than 25 million people.

Case Study

INDIRA SAGAR PROJECT (ISP) - Indira Sagar Project (1000 MW) is in Khandwa district of MP. It is constructed, operate and maintain by Narmada Hydroelectric Development Corporation (NHDC). Narmada is bestowed with rich potential of 29 major, 135 medium and 3000 minor projects. The reservoir of ISP Dam is largest reservoir in India with storage capacity of 12.22 BM^3 of water for irrigation of 2.70 lakh Ha. A total of villages and people affected by this project. They were given plots, transportation grant, shifting facilities, agricultural land and other compensation. A separate township CHANERA was developed for displaced people. Under this project 26000 Ha area is proposed for irrigation, 564 villages to be benefited by irrigation. This will cause the production of 4.00 lakh tonnes of food grains and 10.55 lakh tonnes of other crops every year additionally. Other benefits of the projects are :-

(i) Pisciculture – 1500 tonnes of fish production every year.

(ii) Industrial development – Due to power and irrigation, development of new Industries in Nimar and Malwa region.

(iii) Supply of water to Thermal Power Plant – Water will be supplied to 2000 MW Thermal Power Plant proposed in village Bir.

(iv) Tourism – Resevoir of ISP spread over 913 Sq. km. area will be a boom for tourism development in Madhya Pradesh.

REHABILITATION. The United Nations Universal declaration on Human Rights (Article 25(1) has declared that "Right to housing is basic human right". This suggest better rehabilitation, adequate compensation, job opportunities, civic amenities and religious and cultural benefits. Therefore, National Rehabilitation Policy is needed to honour the human rights of the displaced people. Govt. under Land Acquisition Act 1894 has power to vacate the land from people by giving notice for Govt. use. Therefore, most of the displacements have resulted due to land acquisition by Govt.. There is need of public awareness also in resettlement and rehabilitation plans. In general Govt. and other agencies provide a number of amenities for rehabilitated persons. Every landless person was provided 2 acres agriculture land, Rs 12-18000/- per acre cost of land to displaced person. Rs 20,000 or a plot for residence and 3-5000/- for transportation was also given with certain other compensations.

For displaced persons in case of Indira Sagar Dam, the following compensations for resettlement and rehabilitation were given :-

1. Developed plot or Rs 20,000 for purchase of plot for one family.
2. Rehabilitation grant of Rs 18700/- or 9350/- as per status of PAFs.
3. Transportation grant Rs 5000/- for shifting of one family.
4. Allotted 2-8 hectares of agriculture land per family or land compensation.
5. Attractive compensation for house, trees, wells and other structures.
6. At the plot sites, developed roads, water supply to lights, schools, health centres, worship places, panchayats, community centres, shops etc.
7. R and R work is being executed smoothly.
8. Additionally more benefits were given.
9. Professional training being given to project affected families at I + I Narmada Nagar.
10. Central school (Kendriya Vidyalaya started in June 01)
11. Different socio-economic upliftment programmes such as free medical check up, vaccination, training programmes are being organized.

CLIMATE CHANGE

Though climate is an average weather of an area or environmental factors of an area. These include quantity of light, temperature, humidity, wind, gases, water etc which average for about 30 yrs. Thus the changes in environmental conditions of an area over long period of time is called **climate change**. These changes effect the agriculture, migration of animals, hydrological cycle, thermal gradient between the poles and equator, wind pattern, distribution of rainfall etc.

The scientific and technological revolution has given multiple facilities to mankind, but at the same time man-made(Anthropogenic) activities are responsible for depletion of resources and upsetting the delicate balance between the various components of the environment. They are, excessive use of fossils fuels, deforestation, desertification, loss of fertility of soil, rapid industrialization, increase of automobiles. Changes in the atmosphere conditions resulting in to

serious problems like green house effect, depletion of ozone layer and rise of world temperature etc.

The global change in temperature will not be uniform every where and will fluctuate in different regions. The places at higher latitudes will be warmed up more during late autumn and winter than the places in tropics. Poles may experience 2 to 3 times more warming than the global average, while warming in tropics may be only 50 to 100° C on an average. The increased warming at poles will reduce the thermal gradient between the equator and high latitude regions, decreasing the energy available to the heat engine that drives the global weather machine. This will disturb the global pattern of winds and ocean currents as well as the timing and distribution of rainfall. Shifting of ocean currents may change the climate of iceland and Britain, it may result in cooling at a time when rest of the world warms.

GLOBAL WARMING

The average global temperature is 15°C. The lower most layer of atmosphere i.e., troposphere, traps the heat by a natural process due to the presence of certain gases called **Green house gases**. They are carbon dioxide, ozone, methane Nitrous oxide, Chlorofluorocarbons (CFCs) and water vapours. In absence of these gases the temperature (15°C) would have been - 18°C. Thus warming of the earth's climate owing to the increased concentration of green house gases is called **Green house effect**. Therefore, this effect contributes a temperature rise to the tune of 33°C. These gases act like the glass in the botanical green house trapping the reradiated heat near the earth's surface and warming the planet. These gases along with water vapour and clouds absorbs the infrared radiation, trapping heat near the earth's surface. The two predominant green house gases (1) the water vapours whose level in the troposphere has relatively remained constant is controlled by hydrological cycle while (2) CO_2 whose level has increased is controlled by the global carbon cycle. Other gases whose levels have increased due to human activities are methane, NO and CFCs. Deforestation has also elevated levels of CO_2.

Change the temperature by more than 2°C is disastrous for various ecosystems on the earth including man. Some areas will become inhabitable because of drought or floods following a rise in average sea level.

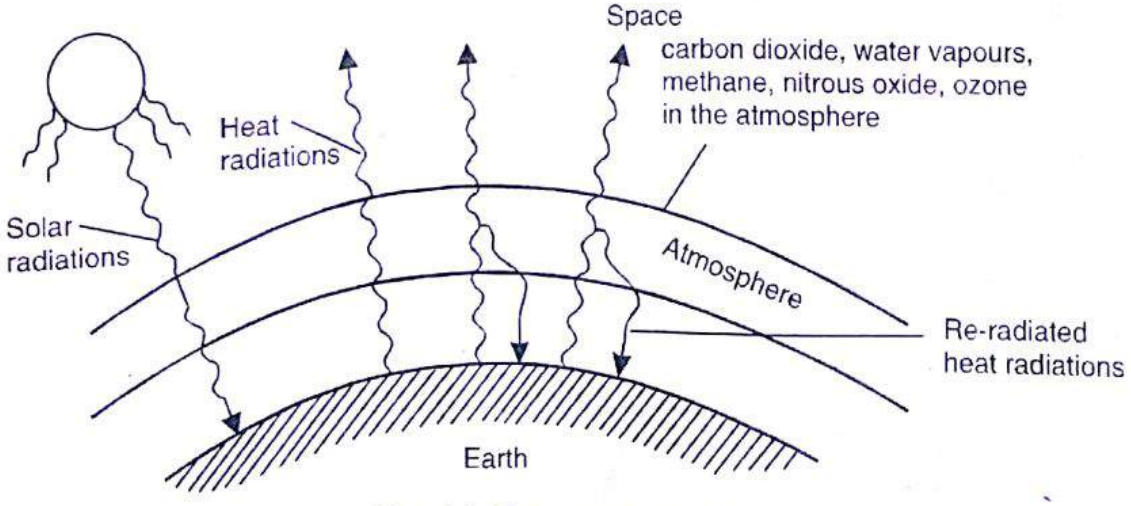


Fig. 6.2 The greenhouse effect

GREEN HOUSE GASES

The green house gases present in the troposphere and resulting in an increase in the temperature of air and the earth are discussed here.

CARBON DIOXIDE (CO_2) – The CO_2 is considered as the most dominant factor responsible for the green house effect. The troposphere contains only 00.0375% CO_2 (by volume) and its amount is controlled by carbon cycle. The four major pools or reservoirs of carbon are fossil fuels, the atmosphere, the biosphere and the oceans. Its concentration in atmosphere has increased from

290 PPM (1860) to 350 PPM (1990) and is expected to be 700 PPM in 2010. It was studied that in 1976 the world consumption of about 5000 million tons of fossil fuels per year was contributing the equivalent of 2.3 PPM of CO_2 to the atmosphere. The net annual increase of CO_2 in the air is 0.77 ppm which indicates that 1.60 ppm of fuel generated CO_2 is being absorbed elsewhere. In last couple of decades the fossil fuels may have contributed more CO_2 to the atmosphere than the terrestrial biosphere. Clearance of forests is another factor for the increase of CO_2.

CHLORO FLUORO CARBONS (CFCs) – The main source of CFCs include leaking air conditioners and refrigerators, evaporation of industrial solvents, production of plastic foams, aerosols, propellants(CFC-11) etc. The concentration of CFCs is rising nearly 5% per year. CFCs trap heat 20,000 times more efficiently than CO_2 and also destroy ozone layer, thus posing a serious twofold environmental problem. CFCs are responsible for 14 – 24% of global warming. It is said (Dickson and Cicerone 1986) that by the end of year 2050 they alone could contribute more than CO_2 to global warming.

METHANE (CH_4) – It is produced in a number of ways including the action of anaerobic bacteria on vegetation, decomposition of organic matter, incomplete combustion of vegetation, natural gas pipeline leaks, burning of biomass during production and uses of oil and natural gas and petroleum oil etc. It is rising approx. 2% every year. It absorbs 20 – 25% times more heat than CO_2.

NITROUS OXIDE (N_2O) – It is released from nylon products, from burning of biomass and fuels (specially coal). From breakdown of fertilizers in soil, livestock wastes and nitrated contaminated ground water, nylon products etc. It is responsible for about 6% of global warming. Besides trapping heat in the troposphere it also depletes ozone in the stratosphere. It absorbs about 250 times more heat than CO_2. The N_2O concentration in atmosphere is 0.3 ppm and is increasing 0.2% annually.

OZONE – It comes mostly from hydrocarbons and nitrogen oxides. It causes irritation to eyes and respiratory organs. It decreases the resistance power to infections and aggrevates illness.

IMPACT OF GLOBAL WARMING

(i) **Climatic change (Increase in global temperature)** – Increase the level of Green house gases causes the global warming have affected the global climate. This effect will increase in future. According to IPCC (1996) the world climate has warmed from 0.3 to 0.6°C during the last century. Over the next century GHGs will increase further by 1°C – 3.5°C December 03 report has predicted the global warming would be 5.5°C higher by 2100 AD. It seems likely that many species will be unable to adjust quickly to global warming and associated climatic change. As a result, biological communities may suffer profoundly. More than 10% of the plant species will not be able to survive. The climatic change also effects rainfall, species composition, plant reproduction cycles and biogeochemical cycles.

(ii) **Effect on Sea levels** – Rising temperatures will cause glaciers to melt and the polar ice caps to shrink. As a result sea level may rise by 0.2 – 1.5 m over the next 50 – 100 yrs. It is proved that sea level have already risen by 10 – 25 cm. If it continues, many low lying areas may be submerged in near future, and it is possible to destroy 20% - 80% of the coastal wetland. Rising sea levels are detrimental to coral reef species, which grow at a precise depth with optimum temperature and water movement. Abnormally high water temperatures in the Pacific Ocean during 1982 – 83 caused the death of symbiotic algae that live inside the coral.

(iii) **Reduction of Biodiversity** – As we have discussed, increased temperatures, inundation of some coastal biological communities and changes in the pattern of distribution of many species over a long period of time are likely to cause reduction in biodiversity in aquatic and terrestrial ecosystems.

(iv) **Effect on Agriculture** – There are different views regarding the effect of global warming on agriculture. It may be positive or negative. However, the effects of this change will vary for C_3 (i.e. wheat, rice and beans) and C_4 (e.g. maize, millet and sugarcane) plants. As temperature increase with rising CO_2 level, some crops may no longer be grown in certain regions. With rise in temperature soil moisture will decrease and evapo-transpiration and pest growth will increase. This will effect certain crops. With increased CO_2 concentration some plants will show increased photosynthesis, greater root production, increased nitrogen fixation in root nodules which may increase the growth of plants by 30%.

(v) **Effect on human health** – The global warming will lead to changes in the rainfall pattern in many areas, thereby effecting the distribution of vector borne diseases like malaria filariasis, elephantiasis etc. Warmer temperature and more water stagnation would favour the breeding of mosquitoes, snails and some insects, which are vectors of such diseases. Higher temperature and humidity will increase respiratory and skin diseases. Keeping in view of ill effects of global warming UNEP (United Nations Environmental Programme) is celecrating 5th June as **"World Environmental Day"** every year since 1989.

(vi) **Effect on Arctic ecosystems** – Global climate change will have profound effects on arctic ecosystems. Tundra is more sensitive to global climate change than most other ecosystems on earth. According to Shaver et al 1992 warmer temperature may increase primary production, thereby increasing Carbon input and soil respiration hence increasing carbon output.

(vii) **Ecological disturbance** – Global warming increases the desert. It increases temperature in North America, South Africa, Mexico, India and other countries. Changes of hurricanes, cyclones and floods will be more which will damage the lagoons, estuaries and coral reefs. Global warming may cause extinction of more than one million species of animals and plants by 2050 A.D.

MEASURES TO CHECK GLOBAL WARMING

To check the global warming following steps are necessary –

(1) Plant more trees (Afforestation)
(2) Control population growth.
(3) Cut down the current rate of CFCs and fossil fuel.
(4) Use of non-conventional source of energy.
(5) Shift from coal to Natural gas.
(6) To trap and use methane as a fuel.
(7) Reduce beef production.
(8) Efficiently remove CO_2 from smoke
(9) Use photosynthetic algae to remove atmosphere CO_2.
(10) Adopt sustainable agriculture.
(11) Use energy more efficiently.

ACID RAIN

Normal rain water is always acidic because of the fact that CO_2 present in the atmosphere gets dissolved in it forming carbonic (H_2CO_3) acid. Because, the presence of SO_2 (Sulphur Dioxide) and NO_2 (Nitrogen Oxide) gases as pollutants in the atmosphere, the pH of the rain water is further lowered (as low as 2.4). This is known as **Acid rain**.

How acid rain is formed

In high temperature combustion processes most of the nitric oxide originates from atmosphere and some Nitric oxide also released by burning of wood and as a result of microbial nitrification in the soil. Lightning is another source of Nitric oxide.

In day time Nitric oxide is oxidized by oxygen, ozone

$$NO + O_3 \longrightarrow NO_2 + O_2$$
$$H_2O \longrightarrow H^+ + OH^-$$
$$NO_2 + OH^- \longrightarrow HNO_3$$

Similarly, formulation of H_2SO_4 acid in the atmosphere can take place with a wide range of reduced as well as partially oxidised Sulphur compounds, H_2S, CS_2 etc. These compounds are released from oceans and soil under reducing conditions. The production of H_2SO_4 from SO_2 may take place homogeneously in the gas phase as :-

$$SO_2 + OH^- + X \longrightarrow HSO_3^- + X$$

Where X = O_2 or N_2 in atmosphere.

The HSO_3^- so formed can undergo a number of reactions, some of which produce sulphuric acid.

$$HSO_3^- + O_2 + X \longrightarrow HOO^- + SO_3 + X$$
$$SO_3 + H_2O \longrightarrow H_2SO_4$$

The hydroperoxy radical HOO^- can also react to give HNO_3

$$NO + HOO^- \longrightarrow NO_2 + OH^-$$
$$NO_2 + OH^- + X \longrightarrow HNO_3 + X^-$$

Thus a number of reactions are taken place, forming different acids.

The chemical composition of rain is highly variable and depends on the geographic location and the influence of natural, anthropogenic chemical processes on the atmosphere of that region.

Effects of acid rain

Acid rain exerts both direct and indirect effects on the organisms and materials it comes in contact with. The dry deposition attacks building material, steel and other metals. When deposited in gaseous form it causes direct damage to plants and trees. Wet deposition has direct and indirect effects. It increases the acidity of lakes and rivers and effects aquatic as well as terrestrial ecosystems. Some of the effects may be described as :-

1. A significant reduction in fish population accompanied by decrease in the variety of species in food chains have been observed.
2. Adirondack ponds having high acidity levels, were among the first to lose fish population.
3. Different species reacts differently to acidified lakes. Adult fish can survive in more acidic water having high concentration aluminium than dry fish.
4. Many bacteria and blue green algae are killed due to acidification, disrupting the whole ecological balance.
5. In 1958 at Europe pH of rain water was 5.0 and in Netherland (1962) was 4.5. It damaged the leaves of plants and trees.

6. Forests of West Germany, Switzerland, Czechoslovakia, Swedish were severely effected by acid rain.
7. In North America and Europe, acid rain destroyed crops and forests, reducing agricultural productivity.
8. Acid rain has retarded the growth of pea, beams, radish, potato, spinach, carrots etc.
9. Modern researches show that acid rain leaches Potassium, Calcium, Magnesium etc essential elements from the top soil.
10. Acid lakes have low levels of phytoplankton.
11. The activity of bacteria and other microscopic animals is reduced in acidic water.
12. Broad leafed pond weeds do not grow in acid water.
13. Acid rain causes extensive damage to buildings and structural materials of marble, lime stone, mortar etc.

    Lime stone attacked as :-

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

    The attack on marble is termed as **Stone-leprosy.**
14. The Taj Mahal in agra is suffering from SO_2, H_2SO_4 and other fumes, pollutants released from Mathura refinery.
15. Acid rain corrodes houses, monuments, statues, bridges, fences, railways etc.
16. Acidification can play havoc with human nervous, respiratory and digestive systems by making the person an easy pray to neurological diseases.

OZONE LAYER DEPLETION

Stratosphere – Troposphere is the part of atmosphere where humans live and other life processes also occur. The stratosphere is the region of space between approximately 15-50 kms above the earth's surface. The gas molecules in the stratosphere act as absorbing centres, moderating the transmission of the solar radiation to the earth. The qualitative as well as quantitative effect of this is an important determining factor with respect to life processes.

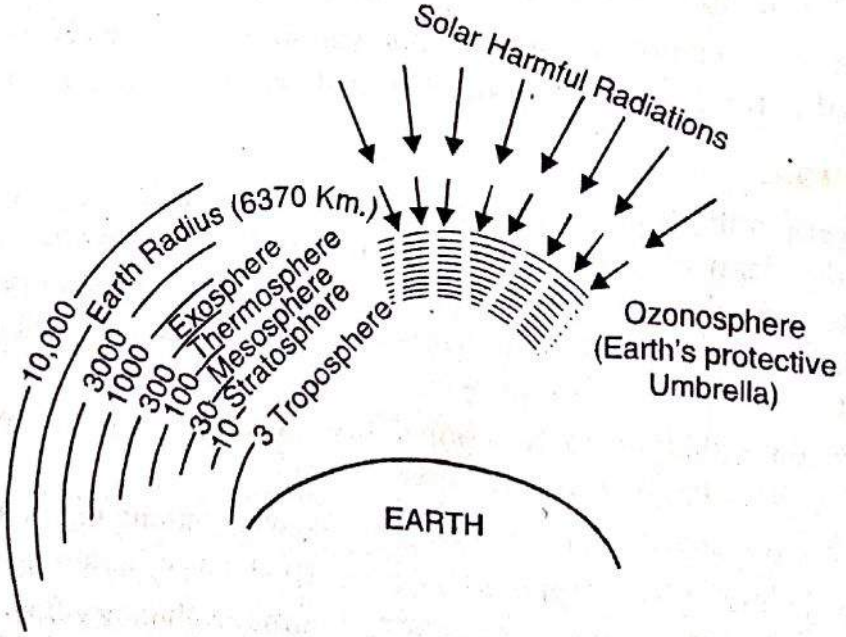


Fig. Atmospheric ozone-earth's protective umbrella.

CREATION OF OZONE LAYER

Ozone is naturally occurring gas found through out atmosphere, with a maximum mixing ratio at the altitude ranging from 15-30 km above the earth. This region is known as ozone layer. Ozone can be toxic to plants and animals but increased concentration has a profound beneficial effect. Both, atmosphere and earth surface are subjected to radiation from sun. These certain radiations are absorbed by atmospheric gases leading to ionization or dissociation of gases. In the lower mesosphere, atmospheric oxygen gets dissociated and subsequently combines with molecular oxygen forming ozone in stratosphere.

The presence of ozone layer in stratosphere is of vital significance for all biota, because the harmful solar radiations such as ultraviolet rays, which are lethal to life on earth are not allowed to enter the earth's atmosphere by ozone layer(or ozone umbrella). In the absence of this ozone layer all the UV rays of sun will reach the earth surface to increase the temperature so that *biological furnace* will turn into *blast furnace*. **Thus the ozone layer strongly absorbs or blocks the short wave ionising ultraviolet rays and so protect the life on earth.** In stratosphere, ozone is an effective filter capable of absorbing UV radiations with wavelength between 200nm and 315 nm.

FORMATION OF OZONE

In the lower mesosphere, the atmospheric oxygen absorbs UV radiation < 240 nm and photo-dissociates in to two oxygen atoms. These atoms subsequently combine with molecular oxygen of upper stratosphere producing ozone. Ozone is also capable of absorbing short wave length UV radiations releasing oxygen atoms.

$$O_2 + h\nu\ (\lambda < 240\ nm) \longrightarrow O + O$$

$$O + O_2 \longrightarrow O_3$$

Decomposition

$$O_3 + h\nu\ (\lambda = 230 - 320\ nm) \longrightarrow O_2 + O$$

$$O + O_3 \longrightarrow O_2 + O_2$$

This mechanism does not necessarily upset the ozone equilibrium because ozone (loss) is compensated by creation of ozone. As a result ozone occurs in 10 ppm concentration in the form of layer in stratosphere. **The thickness of ozone layer is measured in Dobson units (DU), where 1 DU = 0.01 mm of the compressed gas 0°C and 760 mm mercury pressure.**

The average thickness of ozone layer in stratosphere has been estimated to be about 230 DU. It varies marginally with latitude.

MECHANISM OF OZONE DEPLETION

There are two processes –

1. Natural process
2. Anthropogenic process

1. Natural process – A dynamic equilibrium existing between the production and decomposition of ozone molecule constitutes one of the most important mechanism. The heat generated during the reaction causes a rise in temperature. Secondly, the photochemical process absorbs most of the harmful solar UV radiations.

Hence, the atmosphere is heated because of this absorption and the earth's biosphere is shielded from these lethal radiations. Without it, life on the earth would be completely destroyed. The ozone layer acts UV radiations from sun.

Ozone acts as powerful oxidising agent i.e. has ability to remove electrons from other molecules. Surface ozone is also produced by the action of UV radiations in sunlight involving both nitrogen oxides(NO_x) and volatile organic matter (VOM). Ozone also occur in air and water purification plants, oil wax, textiles and in synthetic industries.

2. Anthropogenic process – Some of the natural species moving in to stratosphere has been augmented in recent years by a number of human activities. Many of the processes, which are responsible for ozone layer depletion share a general mechanism of the type –

$$X + O_3 \longrightarrow XO + O_2$$
$$XO + O \longrightarrow X + O_2 \quad \text{Where x = reacting species}$$
$$\text{Net reaction} \quad O + O_3 \longrightarrow O_2 + O_2$$

The most of the common species (above x) have been identified to be free radicals like HO_x, NO_x and ClO_x. Each of these species is capable of destroying the ozone layer. For example, near the stratosphere, the HO_x radicals are responsible for about 70% of the total mechanism of ozone destruction, including the oxygen only process. Around 30 KM atmosphere, the NO_x catalytic decomposition process dominates the ozone destruction.

EFFECTS OF OZONE DEPLETION

(1) With the ozone layer depletion, there is danger of the increase in the flux of ultraviolet radiation over earth's biosphere. They are harmful for man's life.

(2) UV radiations effects biological systems in two ways – one is confined to patches of skin while the other develops in the immune system as a whole.

(3) These kinds of skin cancer, **Basal** cell carcinoma, squamous cell carcinoma and melanoma caused by UV rays.

(4) UV radiations cause sun burns, leukemia and breast cancer.

(5) UV radiations absorbed by cornea and lens in the eye leading to **Photokeratitia** and cataracts.

(6) Ozone at ground level (of low concentration) exerts its toxic effects directly on the lungs.

(7) Ozone exposure has been shown to be associated with lung cancer, DNA breakage.

(8) Photochemical smog is the measure cause of ozone exposure causing urban air pollution posing a threat to human health.

(9) Many micro – phytoplankton's would die because of their exposure to UV solar radiation. The marked reduction in the productivity of phytoplankton's would in turn adversely effect zoo planktons.

(10) The loss of fish population would directly effect the inhabitants of coastal areas.

(11) Ozone is reported to be highly toxic to fish.

(12) UV radiations increases the mortality rate of larvae of zoo plankton's.

(13) Ozone flecking is observed with the plants of grape, citrus and tobacco. At 00.02 ppm it damage tomato, pea, pine and other plants.

(14) Plant proteins are also susceptible to UV injury.

(15) In plants O_3 enters through stomata. It causes visible damage to leaves thereby reducing their photosynthetic rate.

(16) Due to ozone reduction, intense UV radiation causes greater evaporation of surface water through the stomata of the leaves and decreases the soil moisture content.

(17) Ozone reacts with many fibres, such as cotton, nylon and polyester, dyes etc.

NUCLEAR ACCIDENTS AND HOLOCAUST

Japanese towns of Hiroshima and Nagasaki. The first atom bomb was exploded about 580 metres in the atmosphere over ill fated Hiroshima on August 6, 1945. the second atom bomb was detonated 507 metres high in air over Nagasaki. At least 100,000 people were reported killed, severely injured and missing in Hiroshima alone, where the bomb virtually demolished all structures

and buildings in about 15 square km. area. In Nagasaki 49000 civilians were killed, injured and disappeared while an area of 6 to 7 km. was devastated.

The atom bomb exploded on Hiroshima used Uranium (U – 235) with a half life period of 8.5×10^8 years, while the Nagasaki bomb had plutonium (Pu – 239) as an explosive man-made radio-nuclide with half life of 24,000 years.

Exhaustive studies conducted in Hiroshima show that heavily exposed hibakusha, bomb effected people. Have a 30% greater chance than normal of dying from cancer.

This lethal explosion caused millions to die, while thousands became unable to breathe, unable to see and eat. Public suffered from pulmonary oedema, anoxia, brain damage and increased risk of sterility. However, several cases reported high incidence of still births and congenital deformities among pregnant women. Excess cases of leukemia began appearing in 1948, but by the early 1970's the rate leveled off nearly to that of the general population.

The first hydrogen bomb was exploded in 1954 on Bikini Island in the Pacific. The radioactive fallout from this explosion severely affected the crew of a Japanese fishing boat, the Lucky Dragon about 150 km. away from the site of explosion. Several persons were hospitalized, killed and disappeared, while in Bikini Island the explosion caused the entire toll vanished.

In 1957 and 1958, the USA, Soviet Union and Great Britain detonated nuclear weapons whose total yield was about 85 megatons. These weapons were equal to 4250 Hiroshima sized atom bombs. They caused several dangerous effects on man.

In 1961, Russia detonated a bomb of 57 megatons that could obliterate a city more than three hundred times the size of Hiroshima.

Case study

CHERNOBYL ACCIDENT

Chernobyl was the first officially acknowledged nuclear accident in USSR and first reported to the world. April 26, 1986 was a sad day for nuclear power generation when a major accident occurred at 1.23 A.M. in the nuclear reactor at Chernobyl, in the Ukraine area of the Soviet Union. It resulted in clouds of radioactive smoke over a large area in Scandinavian countries which are 2000 km. away in the Russian region itself. There was a devastating fire in the reactor which caused few casualties and severe damage to the nuclear plant. On finding the fire uncontrollable the soviet authorities sought the help of West Germany and other nuclear nations to tackle the situation. Presumably, the core of the nuclear reactor had melted.

The explosion at the **Chernobyl power plant** in Soviet Ukraine, USSR confirmed the worst nuclear disaster. Poor design of the reactor magnified with operator negligence caused the havoc. The operators ignored warnings from various sensors and even disconnected the emergency core cooling systems.

Neutrons went out of control and enormous steam built up in pipes. The explosion sent the graphite slabs of the reactor core through the roof, setting it a fire and spewing radioactive materials around the world.

Twenty percent of the plant's radioactive iodine escaped along with 15 to 20% of radioactive caesium, hazardous plutonium and mixture of several radioisotopes. Radiation level reached 100 times than the normal. Samples of radioactive debris collected in Sweden indicated that some percentage of radiation in the reactor core actually escaped due to which air became frosty and the environment critically polluted. The USSR authorities claimed later that the fire had been controlled and put out.

The vast cloud of radiations caused considerable anxiety in Western Europe. The Soviet Union reported in a statement on April 29, 1986 that two persons were killed and a few injured.

But the senior US official told that the death toll was probably much higher. On May 2nd, the Soviet authorities admitted that 18 persons affected by the leakage of Chronic radiation were in incident were credible. He made this remark after studying a data relayed by US spy satellite which over flew the Ukrainian area where the fire and radiation leak occurred.

A top Swedish nuclear official estimated that "thousands of people could have been killed" around the Chernobyl reactor, 100 km. north of the Ukrainian capital of Kiev in USSR, if all radiations had leaked into the atmosphere. He also reported that water supplies to the homes of 3.5 million persons of Kiev had probably contaminated with acute radionuclides.

Scientists have recently discovered that worms exposed to excess radiations have started copulating instead of reproducing asexually. The **Chernobyl nuclear disaster** has not only affected human being, but has even drastically changed the lives of worms. The finding is the clear evidence of how wildlife is affected by radioactive pollution. Although there is a wealth of knowledge on the impact of ionizing radiation on humans, the effects on wildlife have never been assessed. Many researchers are now focusing on how wildlife has been affected by the radioactive pollution that spewed from a reactor which exploded 17 years ago in Chernobyl. Researchers from Ukraine found that the worms from a lake near Chernobyl had received 20 times more radiation as compared to those from the lake situated far apart. They found some remarkable changes in the sexual habits of worms. According to the scientists, the worms have started sexually reproducing to protect themselves from radiation. Sexual reproduction allows natural selection of genes that offer better protection from radiation damage. A change in sexual behavior may have increased the resistance of the worms.

The **Chernobyl power plant,** the world's worst nuclear accident best symbolizes the potential dangers of atomic energy, has been officially closed on December 15, 2000 – 14 years after the plant exploded and sent a cloud of radioactive dust over Europe. More than 4000 Ukrainians who took part in the hasty clean up effort since the 1986 disaster have died and 70,000 were disabled by radiation, according to government figures. About 3.4 million of Ukraine's 50 million people, including some 1.26 million children, have been affected.

WASTELAND RECLAMATION

The area or land like salt affected, sandy, barren-hill-ridge snow covered or glacial which is economically unproductive suffer from environmental deterioration are called waste lands. These are for one reason or the other do not fulfill their life sustaining potential. Therefore, wasteland should be reclaimed and put to some productive use. About half of our country's geographical area is lying as wasteland. Maximum wasteland area in our country lie in Rajasthan, followed by Madhya Pradesh and Andhra Pradesh.

There are two modes of formation of wastelands :-

1. *Natural Process.* These include undulating uplands, snow covered lands, coastal saline areas, sandy areas etc.

2. *Anthropogenic(Man-made) activities.* These are deforestation, overgrazing, mining and erroneous agricultural practices.

Due to increasing population more land is required for agricultural and forestry. Opposite to it quality land is decreasing due to erosion, desertification, water logging, salinity, toxic effects of agrochemicals and industrial effluents. Now the only way to increase the land resources is by reclamation and developing degraded land. Govt. also planning and giving funding for conservation and regeneration of forest resources. Faulty irrigation specially canal, drainage practices, water logging are also main causes to form wasteland. Indira Gandhi Canal project in Rajasthan has changed water-starved wasteland to water-soaked wasteland.

For reclamation of wasteland in 1985 National Wasteland Development Board (NWLDB) was established. The basic functions of this board, were to check the soil erosion, deforestation and plantation. But later on in 1989-90, the aims of board were re-examined and modified. Now the main objects of board are :-

1. To prevent soil erosion, landslides and flood.
2. To improve the quality, physical structure of marginal soils.
3. To increase the availability of Biomass.
4. To conserve the biological resources of the land for sustainable use.

Wasteland reclamation is development of degraded, mined and unused land for productive purpose. The following are some of the reclamation practices:-

1. *Soil Sodicity* – Sodicity in soil is due to excess of sodium. This can be reduced by use of Gypsom in soil. The calcium of gypsum will replace sodium by exchangeable process.
2. *Use of green – manures and Biofertilizers* – Dhaincha (Sesbania aculeate), Sun hemp (Corolania juncea) or guar etc. should be used as green manures to reduce salinity of soil. Farm yard manure and biofertilizers like blue green algae are also used to reduce salinity.
3. *Irrigation practices* – High frequency, thin and frequent irrigations have been found more useful. Surface irrigation with precise land leveling and smoothening also help to reduce water logging and salinity.
4. *Drainage* – Water logged soils are reclaimed by removing excess of water by artificial drainage. When water stands in fields after heavy rains, the ditches (30 – 40 cm deep at distances of 30 – 50 metres) are provided to runoff the excess of water. This is known as *surface–drainage.* But in *sub-surface drainage* method, perforated PVC pipes or open jointed pipes graved 2-3 metre below the land surface are used. This is better method.
5. *Leading and land development* – this is done in salt affected soil. After land levelling, apply excess of water, which pushes down excess of salts. This loss of extra salts by downward moving water is called leaching.
6. *Selection of tolerant crops* – Tolerance of crops to salt is found to range from sensitive, semi–tolerant, tolerant to highly tolerant. Date-palm, sugar barley are highly tolerant crops, which are not affected by high salinity. Soyabeen, coconut mustard, wheat etc.are salt tolerant. Rice, maize, pulses, sunflower, sugarcane, vegetables etc. are semi tolerant. The different combinations of crops should be grown in saline soil.

There are two successful cases of reclamation of mined area, one is Neyveli Lignite Corporation Ltd in Tamilnadu and other is Stone Quarries of Sayaji Iron Works in Gujarat. The NWLD Board and environment and forest ministry planned a programme for wasteland reclamation. In first phase they selected the five districts-Almorah, Purulia, Bellari, Dungarpur and Sundergarh. During 8th five year programme 13.75 crores of rupees sectioned for 234 projects to NGO's. In 1999-2000, 8 crores of rupees were sanctioned for 3000 hactare wasteland. With the help of retired military personals, Wasteland Development Task Force, 1994 in Morena district of M.P. was started to develop the 12000 hactare Chambal revines.

Consumerism and Waste Products

Consumerism is the consumption of natural resources by the human beings. Exponential increase in consumption of natural resources are there now days as comparison to early period. This is due to increase in life style and population growth. Earlier much simpler life was but now in modern period needs and consumption of resources increased.

In different countries the consumerism of natural resources are not the same. On the basis of consumerism, population have two categories, one is people over population and consumption over population. This is nothing but population influence consumerism of natural resources and generation of wastes.

(A) People over-population – This occurs in less develop countries (LDC) where per capita consumption is less. Because as compared to resources population is high i.e. more people than available supply of food, water and other resources. India has 16% of the world population, hence per capita consumption is 3% waste generation has direct correlation with the rate of consumerism. In India wastes generated are about 3% very less than more developed countries(MDC).

(B) Consumption over Population – It occurs in more developed countries where population is less. Naturally the natural resources will be more as per population. Hence per capita consumption will be high. In other words more food, water and natural resources will be available, results very high wastes generation. The life style will be good as compared to less developed countries. USA, a more developed country has about 4.7% of world population and about 25% waste generation. About 400 million metric tonnes of industrial wastes (other than mining and mineral) and 180 million metric tonnes municipal wastes are in USA.

Thus tremendous amount of stuff thrown away. Much of the wastes can be reused or recycled in other useful products. But in practice easy to throw than environmentally responsible.

The relationship between population size, consumerism and environmental impact was explained by *Paul Ehrlich and John Hodlern (1972)* in following ways –

Environmental Impact = Population size × Per capita use of resources

× Waste generated per unit of resource used

PUBLIC AWARENESS

Environmental pollution, environmental degradation, environmental deterioration, environmental crisis etc. are few words which becoming day by day a subject of concern in every walk of life. This is all due to industrialization, rapid population growth, urbanization, changing life style etc. The formulation of various acts and legislations to control pollution and conserve or protect environment, underlines the will and concern of the Government. But incomplete knowledge, informations and ignorance about many aspects of environment has led to misconceptions. Therefore, it is necessary to make people aware about the laws and legislations and to save environment. There is no single subject by which we can have complete knowledge of environmental aspects. Simultaneously, it can not be done by single man, agency or institution. It is of the people, by the people and for the people. Thus public awareness means, making the people conscious about the physical, social and aesthetic aspects of environment.

Methods –

To protect and conserve the environment is the basic duty of all sections of people because environment belongs to all and every individual matters. Instead of searching the solution, it is necessary to find the permanent solution of environmental and ecological problems. It can be done by following means –

(1) Through mass–media – There are various means of mass communication to educate, entertain & give informations, instructions etc. to people. Radio was the first. Next is T.V. in terms of its reach to the masses. In addition to these newspapers, magazines etc. are also there. Since media has an important role in masses hence awareness among people can be propagate by articles, important serial programmes, instructions, stories etc. using these media. Documentary and films on environmental awareness may be displayed in cinema houses. Posters can also be displayed in streets, on roads and at common places for environmental awareness.

(2) Through Education – Students are the back bone of a country. If environmental education is started from grass root level i.e. from childhood stage, it will give good results. It will be done through formal and informal environmental education. A welcome step to introduce environmental studies paper at collage level by Government by the directive of Supreme Court is good in the direction of awareness.

(3) Through rallies, orientation and training programmes - To promote environmental awareness, environmental rallies with posters, handbills, programmes may be organized on certain occasions like 5th June as world environmental day and 1st week of October as wild life week. Some training programmes, orientation, workshops, seminars, meetings based on environment awareness may be organized for decision makers, planners, leaders also, so that they can also spread the message to protect & conserve the environment.

(4) Through voluntary organizations and NGOs – Due to having link between people and Government some voluntary organizations and non Government organizations can play an important role in the direction of environmental awareness in people by organizing educational, religious, plantation, musical, Nukkad Natak, competitions (essay, drawing, oral) etc. programmes. These organizations can also advise the government to implement effective programmes for environmental awareness. They can organize certain public monuments for conservation of environment. Chipko Movement, Narmada Bachao Andolan, etc. are such public monuments were organized by Dasholi Gram Swaraj Mandal in Gopeshwar and Kalpavriksha respectively. Some voluntary organisations working in this field are –

(1) Bombay Natural History Society (BNHS).

(2) Wild Life Preservation Society of India. (WPSI)

(3) Worldwide Fund for Nature – India (WWF - India).

(4) Centre for Science and Environment (CSE)

In addition to these some scientific and technical societies like Indian Science Congress, National Academy of Sciences, Institution of Chemists, The Indian Chemical Society, Biological Society of India, Pollution Research, CDRI, NEERI etc. are also doing work in the field of public awareness by organizing seminars, workshops, publishing articles, research papers etc.

NGOs usually consists of volunteers or group of individuals genuinely interested in the cause of conservation of wild life and protection of environment. They generate their own resources, contributory funds, grants etc. They play an important role in developing public awareness about environmental matters. These organizations can be grouped in to three categories –

(1) Specialized agencies with restricted membership consisting primarily of scientific and professional members. For example – International Council of Scientific Unions (ICSU), International Union for Conservation of Nature and Natural Resources (IUCN)

(2) Institutes and centres devoted to the task of collection of information, research and consultation. eg. International Institute for Environment and Development etc.

(3) Activist organizations with open membership for the cause of raising support and consensus for wild life protection, are doing for conservation of resources and improvement in the quality of environment. For example Sierra Club National Audubon Society, Bombay National History Society etc.

Human Population and the Environment

INTRODUCTION

A population may be defined as a group of organisms of the same species occupying a given area at the same time. It is subdivided in to demes or local populations, which are groups of interbreeding organisms or the smallest collective unit of a population. A population may consist of either *unitary* or *modular organisms*. Insects, fish amphibians, birds, mammals are examples of unitary organisms where each individual is produced from a zygote and the form and development of individuals is highly predictable. But in modular organisms, the zygote develops in to a unit of construction or module, which produces further modules to form a branching structure, therefore form and development of individuals are unpredictable. Sponges, Corals and plants are examples of modular organisms.

POPULATION GROWTH

The most important freatures of population is the growth i.e. the capacity of increase in individual members. By measuring the size or density of a given population from time to time, we can get rate of increase and can also predict future changes in its size. It can be defined in following ways—

(*a*) Logistic growth : When a population is allowed to grow in a limited space (environment) it shows logistic growth. If we plot a graph between number of bacteria or cells against time, we find a typical S shaped sigmoid curve called population growth curve.

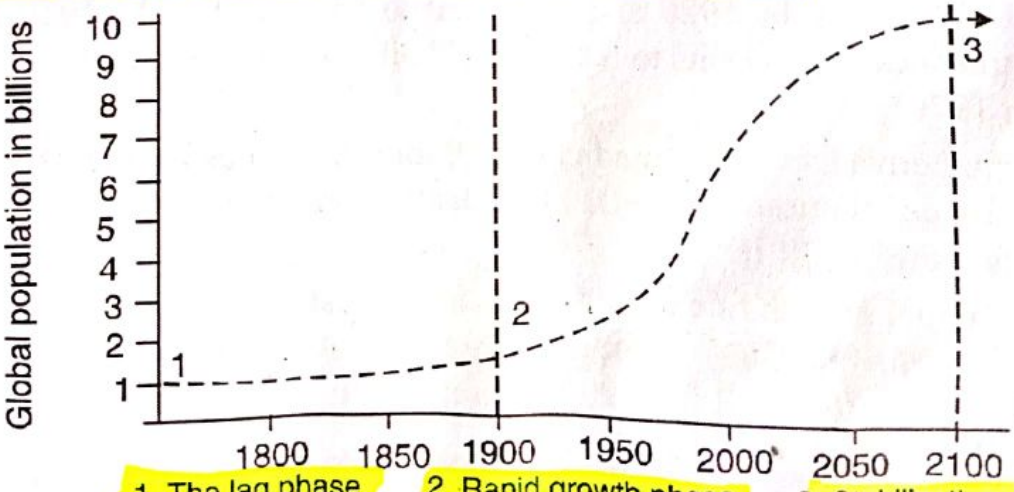


Fig. 7.1. The three phases of growth of human population

It has four phases i.e. Ist phase shows slow rate called lag period, second is accelerating stage followed by a phase of extremely rapid population. The last phase is accelerating multiplication followed by equilibrium phase where is essentially no net change in population called saturation level or carrying capacity. It is represented by letter K.

The logistic equation shows density dependent growth i.e. growth of a simple population in a limited space with limited resources. It may be written as—

$$dN/dt = \gamma N(1 - N/K)$$

where dN/dt = rate of growth of population

γ = intrinsic rate of increase (per individual of population)

N = Population size (No. of organisms in population at time t)

K = Carrying capacity of population

$(1 - N/K)$ = density – dependent factor.

(*b*) Exponential Growth : When a population growth curve quickly begins to rise very steeply, the population shows exponential growth. It is J shaped (Fig.7.1). A population growing exponentially increases accordingly to the equation

$$N_t = N_0 e^{rt}$$

where N_t = The number of individuals in the population after t units of time

N_0 = initial population size (t = 0)

r = exponential growth rate

e = the base of the natural logarithm (about 2.72)

(*c*) Geometric Growth : Geometric growth may be defined as the population growth in which the rate of increase is proportional to the number of individuals in the population at the beginning of the breeding session. When young ones are added to the population only at specific times of the year during well defined reproductive periods, the population is said to have geometric growth. The equation for this is

$$N_t = N_0 \lambda$$

where λ = the geometric growth rate.

POPULATION EXPLOSION

As we have seen growth rate of a population is expressed as the number of individuals by which the population increases divided by the amount of time that elapses i.e.

$$\text{Growth rate } (r) = \frac{\text{No. of birth } (b) - \text{Number of deaths } (d)}{\text{average population in time interval}}$$

There are many cases where b is substantially large than d for a period of time, following which conditions change so that d becomes much larger than b. This sort of variations are exponential

called "**Population explosion**" during favourable conditions, followed by a **"Crash"** when conditions change. For example, diatom populations in Lake Michigan USA undergo such exponential increases at different time of years.

In 20th century population growth increased too much. This is also called population explosion. Economist Malthus said, resources increases 1, 2, 3, 4, ... while population increases 2, 4, 6, 8, ... respectively. In India population growth is much more than twice. Fertility period is of 30 yrs (from 16 to 46 yrs of age). World population is also increasing day by day is 150 per minute 220,000 in one day. Growth rate is 2.2%, with this population will go 7 billion by 2010. World population increase by 9 crore 20 lac per year i.e. one Maxico every year. Do we have the resources and provisions for feeding, housing, educating and employing all those people being added every year. On 11th May 2000 we become one billion i.e. one person out of every 6 persons in this world.

Our resources like land, water, fuels, minerals, forests grasslands etc. are limited and due to population explosion these resources are getting exhausted. Social, economic, religious all type of reasons are responsible for the high rate birth in our country. The important reasons are lower marriage age, lack of education, joint family system, importance of male child, religous misbelieves, decline in death rate, increased protection of life from natural risks, increase life span, better means of transport and other facilities.

Due to overpopulation some serious problems are like food supply, space (accomodation), unemployment, education, human health, energy crisis etc. There is a fierce debate on population explosion to reduce fertility rates through world wide birth control programmes. This can be achieved by proper education, mass media, educational institutions, raising the marriage age from 18 to 22, providing the facilities like contraceptives, intra uterine devices, birth control pills, sterilization etc. Family planning programme which is Govt. sponsored programme is also one of the effective means to reduce fertility. It was started in India in 1951.

NATIONAL FAMILY WELFARE PROGRAMME

Previously this programme was known as National Family Planning Programme. In the year 1977 the name was changed to *National Family Welfare Programme*. Family planning programme was launched in India in 1952. India was the first country to do so.

Beginning of the programme was modest, i.e., establishment of few FP clinics, distribution of FP educational material, training of health functionaries and research. During the third 5-year-plan (1961-66) family planning was declared as *centre of planned development.* Then the emphasis was shifted from *clinic approach to extensive education approach* (i.e., motivating people about *small family norm*). A separate Department of Family Planning was created in 1966 in the Ministry of Health. In 1972, the MTP Act was passed. In April 1976, National Population Policy was framed.

During the emergency period (1976), forcible sterilisation campaign led to the defeat of Congress in 1977 elections. In June 1977, new Janata Government formulated *a new population policy* and made family planning as voluntary and renamed it as *Family Welfare Programme.*

The acceptance of primary health care approach as the key to the achievement of health for all by 2000 AD led to the formulation of National Family Welfare Programme in 1982.

Importance of Family Welfare Programme

1. The family welfare programme occupies an important position in the nation's socio-economic development.

2. Indian population which was 34 crores in 1947 has crossed 100 crore mark by 2000 AD. India has only 2.4% of world's land area but it supports about 15.5% of world's population.

3. India's population is increasing by 1.8 crores every year. To check this galloping growth, the country has laid down long-term demographic goal of achieving an NRR of one by the year 2000 AD.

4. Acceptance of the family welfare services is made voluntary.

5. The programme was 100% centrally sponsored scheme. FP programme was integrated with the MCH services.

ORGANISATIONAL SET UP

1. Central level

At central level Central Cabinet Subcommittee is present. It is headed by Prime Minister. Next level is Population Advisory Council. This is headed by Union Minister of Health and Family Welfare. Members are representatives of various professional bodies and some technical persons. Next level is Central Family Welfare Council, which is headed by union minister and ministers of health and family welfare of all states. It coordinates the work of the programme.

National Institute of Health and Family Welfare, situated in Delhi, is the apex institure. It undertakes research and training in family welfare. Directorate General of Health Services was the central programme officer for Family Planning. He advises Government of India on various aspects of family welfare.

2. State level

Ministry of Health and Family Welfare is the apex organization at the state level. This is headed by the minister of health and family welfare of the respective state. At the state level the family welfare work is organised by State Family Welfare Bureau. The State Family Welfare Bureau has three wings:

(a) Administrative wing (headed by state family welfare officer and associated by some officers)

(b) Education and information wing (headed by mass media information officer)

(c) Field operation and evaluation wing (headed by statistical officer).

3. District level

At district level the work of family welfare is organized by *District Family Welfare Bureau.* This has three wings like the state level. At some districts *Regional Family Welfare Training Centres* are present. These will undertake training of medical officers and para-medical staff.

4. Peripheral level

In rural areas the family welfare work is looked after by *rural family welfare centres* attached to PHC while in urban areas *urban family welfare centres* will took after this work.

5. Village level

At village level the MPHA(F) and MPHA(M) are mainly responsible for the programme. They will take the assistance of CHG, TBA and anganwadi workers.

Goals of National Population Policy

1. NRR 1 (which implies two-child norm)
2. Birth rate 21/100 population
3. Death rate 9 per 1000 population
4. Raising couple protection rate to 60%
5. Reduction of family size to 2.3
6. Decrease the IMR to 60 per 1000 live births.

Programme Strategies

1. Integrated approach
2. Cafetaria approach
3. Welfare approach

VALUE EDUCATION

INTRODUCTION—Man acts to satisfy his needs or wants. Any thing which satisfies a human need becomes thereby a thing of **Value.** It is the element of desirability and satisfaction that is common to all values, material or non material. In psychology the term value is generally employed to designate a dominant interest, motive or broad evaluative attitude. Value has been defined variously by different educationists, but on the whole it is interpreted to be either a set of feeling or an action. Human behaviour is governed by his values. These are socially approved desires or goals, conceptions or standards by which things are approved or disapproved. Value is a dynamic term used in different aspects. Indian philosophy has used it in sense of state free from pleasure and pain, psychologists in the sense of "psychic energy", sociologists in the sense of "use of time, energy and money" for certain ends. The last theory is named as "Integral theory".

The progress and development of a nation depends upon the quality of the values cherished by its citizens. One of the serious criticism against our educational system is that it lacks value orientation. Our 1986 National Policy on Education and its modifications have strongly advocated value education.

IMPORTANT VALUES

Important values may be described as follows—

(*i*) **Religious Value :** It is defined in terms of faith in God. The outward acts of behaviour expressive of this value are going on pilgrimage, is linking in simple life, having faith in religious leaders, worshipping God and speaking the truth. Students (Higher studies) prefer least the religious value.

(*ii*) **Social Value :** It is defined in terms of cherity, kindness, love and sympathy for the people, efforts to serve God through the service of mankind, sacrificing personnel comforts and gain to relieve the needy and affected of their misery.

(*iii*) **Democratic Value :** This value is characterized by respect for individuality, absence of discrimination among persons on the basis of sex, language, religion, caste, colour, race and family status, ensuring equal social, political and religious rights to all and respect for all democratic institutions.

(*iv*) **Aesthetic Value :** It is characterized by appreciation of beauty, from proportion and harmony, love for fine arts, drawing painting, music, dance, sculpture, poetry and architecture, love for literature, decoration and the surroundings. It is also the least preferred values in schools.

(*v*) **Economic Value :** This value stand for desire for money and material gains. A man with high economic value is guided by consideration of money and material gain in the choice of his job.

(*vi*) **Knowledge Value :** This value stand for love of knowledge or theoretical principles of an activity and love of discovery of truth. A man with this value considers a knowledge of theoretical principles underlying a work essential for success in it. He values hard work in studies.

(*vii*) **Hedonistic Value :** It is the conception of desirability of loving pleasure and avoiding pain. For a hedonist the present is more important than the future. He indulges in pleasure of senses and avoids pain.

(*viii*) **Power Value :** It is defined as the conception of desirability of ruling over others and also of leading others. A man with this value prefers a job where he gets opportunity to exercise authority over the others.

(*ix*) **Family Prestige Value :** It is defined as the conception of desirability of such items of behaviour roles, functions and relationship as would become one's family status. It implies respect for roles which traditionally charateristic of different castes of Indian society.

(*x*) **Health Value :** It is the consideration for keeping the body in a fit state for carrying out one's normal duties and functions. It also implies the consideration for self preservation.

CO-CURRICULAR ACTIVITIES

The schools should plan their co-curricular activities also from the point of view of value-education. Through these activities many values can be inculcated profitably. Co-curricular activities form an integral part of the modern school curriculum. Various games and sports not only provide the best recreation but they have profound impact on the temperament and outlook of the players. They help in the sublimation of the personality of players. Training in physical education develops the high sense of obedience which leads a person to render his services sincerely. Besides games and sports, there are several out-door activities like N.C.C., P.E.C., N.S.S., scouting and guiding, mountaineering, trekking which train individuals in team work, self discipline, courage, bravery, obedience, integrity and friendship. Students may learn how to serve others and how to respect labour through these activities.

Apart from the above activities literacy and cultural activities may be organised in the schools for inculcating certain values. Poem recitation, debate, symposium, essay competition, work parliament, science club, story competition, melo-drama, mono-acting, socio-dance, music, fancy dress show, painting competition, group dance etc. will offer opportunities to children to learn qualities of leadership, self-discipline, co-operation etc. Morning Assembly has been found to be very good tool for clarification and communication of certain values. If it is conducted properly, it may prove to be very purposive and fruitful for fostering social moral and spiritual values. The sanctity and dignity of the morning assembly should be maintained both by teachers and students and all must participate in it.

Students' sensitivity to the feelings of others are to be increased. They should be provided with the opportunities in the school campus to talk about feelings, to identify with the feelings of other people and to react emotionally themselves. In short, teachers should encourage and help students to participate in experiences that allow them to feel different kinds of emotions, to come into contact with many different people, to do different things and then to share their perception of these experiences.

HIV/AIDS

Key words & Definitions :

AIDS = Acquired Immuno Deficiency Syndrome

Acquired = which is not present since birth but acquired after birth.

Immunodeficiency = Deficiency of immune functional cells; deficiency to perform the immunological function.

Syndrome = A group of diseases and signs and symptoms of illness.

HIV = Human Immunodeficiency Virus

HIV positive = The presence of antibodies against HIV in human body is termed as HIV positivity and the person is called HIV positive (Seropositive). It takes 6-12 weeks after infection for antibodies to rise to detectable levels. There is thus a window period during which the infected person may transmit the infection despite being seropositive.

The latest killer disease that has created nightmares for the medical experts is the Acquired Immuno Deficiency Syndrome (AIDS). Its terrifying spread has earned it the title of the "Pandemic" or an epidemic, which is out of control. This disease has wreaked the social & economic devastation. In the absence of medical defence against AIDS, public education is the only weapon in the fight to limit the spread the infection. Only by influencing personal behaviour & life style can we hope to maintain the ravages of AIDS throughout.

HIV IS NOT TRANSMITTED BY:

Shaking hands, hugging, dry kissing, sneezing, coughing, mosquito bite, toilet sharing, sharing of telephones, offices, playing, traveling together, sharing cups, living in same room, donating blood aseptically.

Water Quality Standards

The Water Quality Standards as set by Union Health Ministry and followed by APHED are:

(i) Physical, (ii) Chemical, (iii) Bacteriological, (iv) Virological

PHYSICAL STANDARDS

No.	Characteristics	Acceptable*	Cause for Rejection*
(i)	Turbidity (units on J. T. U. Scale)	2.5	10
(ii)	Colour (units on platinum-cobalt scale)	5.0	25
(iii)	Taste and odour	Unobjectionable	Unobjectionable

CHEMICAL STANDARDS

No.	Characteristics	Acceptable*	Cause for Rejection*
(i)	pH	7.0-8.5	6.5-9.2
(ii)	Total dissolved solids (mg/*l*)	500	1500
(iii)	Total hardness (as $CaCO_3$) (mg/*l*)	200	600
(iv)	Chlorides (as Cl) (mg/*l*)	200	1000
(v)	Sulphates (as SO_4) (mg/*l*)	200	400
(vi)	Fluorides (as F) (mg/*l*)	0.1	1.5
(vii)	Nitrates (as NO_3) (mg/*l*)	45	45
(viii)	Calcium (as Ca) (mg/*l*)	75	200
(ix)	Magnesium (as Mg) (mg/*l*)	> 30 (If there are 250 mg/*l* of sulphates, Mg content can be increased to a maximum of 125 mg/*l* with the reduction of sulphates at the rate of 1 unit per every 2.5 units of sulphates)	150
(x)	Iron (as Fe) (mg/*l*)	0.1	1.0
(xi)	Maganese (as Mn) mg/*l*)	0.05	0.5
(xii)	Copper (as Cu) (mg/*l*)	0.05	1.5

(xiii)	Zinc (as Zn) (mg/*l*)	5.0	15.0
(xiv)	Phenolic compounds (as phenol) (mg/*l*)	0.001	0.002
(xv)	Anionic detergents (as MBAS) (mg/*l*)	0.2	1.0
(xvi)	Mineral oil (mg/*l*)	0.01	0.3
(xvii)	Arsenic (as As) (mg/*l*)	0.05	0.05
(xviii)	Cadmium (as Cd)(mg/*l*)	0.01	0.01
(xix)	Chromium (as hexavalent Cr) (mg/*l*)	0.05	0.05
(xx)	Cynides (as CN) (mg/*l*)	0.05	0.05
(xxi)	Lead (as Pb) (mg/*l*)	0.1	0.1
(xxii)	Selenium (as Se) (mg/*l*)	0.01	0.01
(xxiii)	Mercury (total as Hg) (mg/*l*)	0.001	0.001
(xxiv)	Polynuclear aromatic hydrocarbons (PAH) (pg/*l*)	0.2	0.2
(xxv)	Gross alpha activity (pCi/*l*)	3	3
(xxvi)	Gross beta activity (pCi/*l*)	30	30

Note 1 : The figures indicated under the column 'acceptable' are the limits up to which the water is generally acceptable to the consumers.

Note 2 : It is possible that some mine and spring waters may exceed these radio activity limits and in such cases it is necessary to analyze the individual radionuclides in order to assess the acceptability or otherwise for public consumption.

*Figures in excess of those mentioned under 'acceptable' render the water not acceptable, but still may be tolerated in the absence of alternative and better source up to the limits indicated under column 'cause for rejection' above which the supply will have to be rejected.

DISSOLVED OXYGEN IN WATER (DO)

Since Oxygen is necessary for all living/non-living organisms, but dissolved oxygen in water is vital to fish and other aquatic life. Oxygen is transferred from atmosphere to surface water as well as produced by aquatic plants, algae and phytoplankton as a bye product of photosynthesis. After dissolving in water oxygen diffuses or distributed throughout the water body. Distribution depends on movement of water, currents and thermal upwelling. Oxygen in water measured as dissolved oxygen (DO). It is measured as parts per million (ppm), which is the number of oxygen (O_2) molecules per million total molecules in a sample.

It is also defined as the number of moles of molecular oxygen (O_2) dissolved in a litre of water at a temperature. It is expressed as mg O_2 / *l*. Dissolved oxygen can range from 0-18 mg O_2 / *l*. Most natural water systems require 5-6 mg O_2 / *l*. The oxygen is used by plants and animals for respiration and by the aerobic bacteria which consume oxygen during the process of decomposition. A high percentage of dissolved oxygen is conducive to aquatic flora & fauna. A low percentage indicates a negative impact on a body of water which results in a abundance of worms and fly larvae.

Factors Affecting Dissolved Oxygen

The following are the main factors which affects the dissolved oxygen (DO) in the water :

1. Water temperature.
2. Flow.
3. Aquatic plant population.
4. Atmospheric pressure.
5. Human Activities.
6. Water discharge.
7. Organic waste.
8. Runoff from streets.

Winkler's Method for DO Determination

The most precise and reliable titrimetric procedure for DO analysis is the Winkler's method (1888). It is the same as iodometric technique. It is based on the fact that dissolved oxygen oxidises Potassium Iodide (KI) to Iodine, which is titrated against standard sodium thiosulphate (Hypo) solution using starch as an Indicator. Since dissolved oxygen is in the molecular state, her.ce can not oxidise as such. For that Manganese hydroxide is used as an oxgen carrier to bring out the reaction. Manganese hydroxide is obtained by the action of KOH with Manganese sulphate.

$$MnSO_4 + 2KOH \rightarrow Mn(OH)_2 + K_2SO_4$$

$$2Mn(OH)_2 + O_2 \rightarrow 2MnO(OH)_2$$

$$MnO(OH)_2 + H_2SO_4 \rightarrow MnSO_4 + 2H_2O + [O]$$

$$2KI + H_2SO_4 + [O] \rightarrow K_2SO_4 + H_2O + I_2$$

$$2Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + 2NaI.$$

For oxidising and reducing agents present in water, two modification are given:

(i) Alsterberg's Modification : If oxidising agents like nitrate and ferric ions are present in water, they will oxiside I to I_2 and will give positive error. To over come with this problem sodium azide is used in alkaline solution to decompose them.

$$2NaN_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2HN_3$$

$$HNO_3 + HN_3 \rightarrow N_2O + N_2 + H_2O$$

(ii) Rideat-Stewart Modification : If reducing agents like Fe^{+2}, SO_3^{-2}, S^{-2} etc. are present in sample. They will reduce I_2 to I^- and will produce negative error.

To overcome with this problem, $KMnO_4$ is used for pretreatment. Excess of $KMnO_4$ can be removed by reaction with Potassium oxalate.

CHEMICAL OXYGEN DEMAND (COD)

Chemical Oxygen Demand is a useful measure of water quality. It is defined as the amount of oxygen consumed under specified conditions in the oxidation of organic & oxidisable inorganic matter. COD expressed in milligrams per litre *(mg/l* or ppm).

COD of waste water is the number of *mg* of oxygen required to oxidise the impurities present in 1000 ml of waste water using strong oxidising agent like acidified $K_2Cr_2O_7$. COD represents the total amount of oxygen required to oxidise all oxidisable impurities in a given sample. Thus COD value for a sample is always higher than BOD value. Since time required for COD test is less, therefore it is always advantageous. In environmental chemistry COD test is indirect measure of organic compounds present in water.

Limitations of COD

COD test does not differentiate between bio-inert and biodegradable materials. It also not indicate the rate at which the biologically oxidisable material stabilize.

COD represents the total amount of oxygen required to oxidise all oxidisable impurities in a sample of sewage wastes COD is always greater than BOD since in COD measurement both biodegradable and non-biodegradable load are completely oxidised. The difference in COD and BOD is equivalent to the quantity of biologically resistant organic matter.

DETERMINATION OF COD

Principle

A known volume of the wastewater sample is refluxed with a known excess of $K_2Cr_2O_7$ solution in H_2SO_4 medium containing $HgSO_4$ (catalyst) and Ag_2SO_4 [which retains halides] for about $1\frac{1}{2}$ hr for the oxidation to be complete. A part of the $K_2Cr_2O_7$ is used up for the oxidation

of impurities. The remaining $K_2Cr_2O_7$ is determined by titration with standard FAS (Ferrous Ammonium Sulphate) solution using ferroin as indicator. The endpoint is the change of colour from blue green to reddish brown.

A blanks is performed by titrating known volume of the acidified $K_2Cr_2O_7$ with the same FAS using the same indicator.

$$\text{COD of water sample} = \frac{(A - B) \times M \ 8000 \text{ ml}}{\text{Volume of sample}} \text{ mg/}l$$

where A = Blank titre value of $K_2Cr_2O_7$ vs FAS and
B = Volume of FAS consumed for unreacted $K_2Cr_2O_7$ of the solution.
M = Molarity of FAS solution.

Procedure

25 ml of waste water is pipette out into a round bottomed flask. 10 ml of $K_2Cr_2O_7$ is pipette out into the same flask along with one test tube full of 1 : 1 H_2SO_4 containing $HgSO_4$ and Ag_2SO_4. The flask is filled with a reflux water condenser and the mixture is refluxed for 2 hours. The contents are cooled and transferred to a conical flask. 5 drops of ferroin indicator is added to it and titrated against FAS taken in the burette till the colour changes from blue green to red brown. Same volume of $K_2Cr_2O_7$ is pipette out, mixed with sulphuric acid and ferroin and titrated against same FAS to get blank titre value.

Calculation

$$\text{Chemical oxygen demand of water} = \frac{(A - B) \times M \times 8000}{V}$$

where A = FAS (ml) used for blank
B = FAS (ml) used for sample
M = Molarity of FAS
V = Volume of sample (ml)

BIOLOGICAL OXYGEN DEMAND (BOD)

Biological Oxygen Demand (BOD) is a measure of water quality. It is an important property. It is defined as a measure of oxygen needed (in mg/litre or ppm) by bacteria and other micro-organisms oxidise the organic matter present in water sample over a period. It may also be defined as the quantity of dissolved oxygen required by aerobic bacteria for the to oxidation of orgahic matter under aerobic conditions. The BOD of drinking water is less than one while sewages have more then several hundreds.

BOD is high, the dissolved oxygen becomes low. The greater the BOD, greater the pollution. Thus BOD is an indication of extent of pollution.

Micro-organisms such as bacteria and fungi are responsible for decomposing organic waste *i.e.,* dead plants, leaves, grass, manure, sewage or food waste. In this process much of the available dissolved oxygen is consumed by aerobic bacteria, robbing other aquatic organisms of the oxygen they need to live. The temperature of the water can also contribute to high BOD levels. Similarly Nitrates and Phosphates in a body of the water can contribute to high BOD levels.

Limitations of BOD

Effluents of industries like paper, pulp rayon & chemicals, have low value of BOD, although they contain enough organic matter. Thus BOD values should not be used as equivalent to organic load. In these cases COD reveals the real pollution potential.

BOD by Winkler's Method

Principle

Winkler's method is based on the fact that in alkaline medium, DO oxidises Mn^{2+} to Mn^{4+}, which in acidic medium oxidises I^- to free iodine. The amount of iodine released which can be titrated with a standard solution of sodium thiosulphate, is thus equivalent to the DO originally present.

The following reactions takes place:

Manganous sulphate reacts with the potassium hydroxide-potassium iodide (alkaline-iodide) to produce a white flocculent precipitate of manganous hydroxide:

$$MnSO_4 + 2KOH \rightarrow Mn(OH)_2 \text{ (white)} + K_2SO_4$$

DO in the water reacts with $Mn(OH)_2$ immediately to form a brownish manganic oxide flocculate (ppt)

$$2Mn(OH)_2 + O_2 \rightarrow 2MnO(OH)_2 \text{ (brown)}$$

If the precipitate is white there is no DO.

Manganic oxide reacts with added H_2SO_4 to give manganic sulphate $[Mn(SO_4)_2]$ as the product of this reaction:

$$2MnO(OH)_2 + H_2SO_4 \rightarrow 2Mn(SO_4)_2 + 6H_2O$$

The $Mn(SO_4)_2$ immediately reacts with the potassium iodide (KI) (added initially as part of alkali-iodide), liberating the iodine exactly equivalent to the number of moles of oxygen present in the sample. The release of iodine (12) imparts a brown coloration of iodine.

$$2Mn(SO_4)_2 + 4KI \rightarrow 2MnSO_4 + 2K_2SO_4 + 2I_2$$

The liberated iodine is titrated with thiosulphate and the reaction is :

$$2S_2O_3^{2-} + I_2 \rightarrow S_4O_6^{2-} + 2I^-$$

From the above stoichiometric equations, we can find that:

$$1 \text{ mole of } O_2 = 2 \text{ moles of } MnO(OH)_2 = 2 \text{ moles of } I_2 = 4S_2O_3^{2}$$

Therefore, after determining the number of moles of iodine produced we can determine the number of moles of oxygen molecules present in the water sample. Dissolved oxygen concentrations are generally expressed in mg O_2/L.

From the titre values BOD is calculated.