LECTURE NOTES

ON

ENVIRONMENTAL STUDIES

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Mrs. K. Rajya Lakshmi, **Assistant professor**

CHADALAWADA RAMANAMMA ENGINEERING COLLEGE

(AUTONOMOUS)

Chadalawada Nagar, Renigunta Road, Tirupati – 517 506

Department of Freshman Engineering

Unit-1

'Environment[3] is derived from the French word '**enviroher**' which means to encircle or surround. All the biological and non-biological things surrounding an organism are thus included in environment. Thus en**vi**ronment is sum total of water, air and 1and, inter-re1ationships among themse1res and a1so with the human beings, other 1iring organ- isms and property.

Scope

Scope of environmental studies is broad based and it encompasses a large number of areas and aspects, broadly listed below:

- Natural Resources—their conservation and management
- Ecology and biodiversity
- Environmental pollution and control
- Social issues in relation to development and environment
- Human population and environment

These are the basic aspects of Environmental Studies which have a direct relevance to every section of the society. Environmental studies can be highly specialized also which may concentrate on more technical aspects like Environmental Science, Environmental Engineering, Environmental Management, Environmental Biotechnology etc.

Need for Public Awareness

The United Nations Conference on Environment and Development held in Rio de Janeiro in 1992 and popularly known as 'Earth Sum- mitt' followed by the world Summit on Snstainab1e Dere1opment at Johannesburg in 2002, just 10 years after the first summit, have high- lighted the key issues of global environmental concern and have attracted the attention of the general public towards the deteriorating environment. Any government at its own level cannot achieve the goals of sustainable development until the public has a participatory role in it.

En 1991, the Supreme Court of our country issued directive to make all curricula environment-oriented. This directive was, in fact, in response to a Public Interest Litigation (PEL) filed by M.C. Mehta vs. Union of India (1988) that prompted the apex court to give a mandate for creating environmental awareness among all citizens of India.

Natural Resources

Life on this planet earth depends upon a large number of things and services provided by the nature, which are known as Natural resources. Thus water, air, soil, minerals, coal, forests, crops and wild life are all examples of natural resources.

The natural resources are of two kinds:

- **Renewable resources** which are inexhaustive and can be regenerated within a given span of time e.g. forests, wildlife, wind energy, biomass energy, tidal energy, hydro power etc. Solar energy is also a

renewable form of energy as it is an inexhaustible source of energy.

- **Non-renewable resources** which cannot be regenerated e.g. Fossil fuels like coal, petroleum, minerals etc. Once we exhaust these reserves, the same cannot be replenished.

The major natural resources:

(1) Forest resources (2) Water resources (3) Mineral resources (4) Food resources
(5) Energy resources (6) Land resources.

FOREST RESOURCES

Forests are one of the most important natural resources on this earth. Covering the earth like a green blanket these forests not only produce innumerable material goods, but also provide several environmental services which are essential for life.

About 1/3rd of the world³s land area is forested which includes closed as well as open forests. Former USSR accounts for about a 7th of the world³s forests, Brazil for about a 7th and Canada and USA each for 6-7%.

■ USES OF FORESTS

Commercial uses: Forests provide us a large number of commercial goods which include timber, firewood, pulpwood, food items, gum, resins, non-edible oils, rubber, fibers, lac, bamboo canes, fodder, medicine, drugs and many more items, the total worth of which is estimated to be more than $ 300 billion per year.

Half of the timber cut each year is used as fuel for heating and cooking. One third of the wood harvest is used for building materials as lumber, plywood and hardwood, particle board and chipboard. One sixth of the wood harvest is converted into pulp and used for paper industry. Many forest lands are used for mining, agriculture, grazing, and recreation and for development of dams.

Ecological uses: While a typical tree produces commercial goods worth about $ 790 it provides environmental services worth nearly
$ 196, 270.

The ecological services provided by our forests may be summed up as follows:

- **Prodnction of oxygen:** The trees produce oxygen by photo- synthesis which is so vital for life on this earth. They are rightly called as earth³s lungs.
- **Redncing global warming:** The main greenhouse gas car- bon dioxide (CO_2) is absorbed by the forests as a raw material for photosynthesis. Thus forest canopy acts as a sink for CO_2 thereby reducing the problem of global warming caused by greenhouse gas CO_2.

- **wild life habitat:** Forests are the homes of millions of wild animals and plants. About 7 million species are found in the tropical forests alone.
- **Regulation of hydrological cycle :**
- Forested watersheds act like giant sponges, absorbing the rainfall, slowing down the runoff and slowly releasing the water for recharge of springs. About 70-80 %of the moisture in the air above tropical forests comes from their transpiration which helps in bringing rains.
- **Soi1 Conservation:** Forests bind the soil particles tightly in their roots and prevent soil erosion. They also act as wind- breaks.
- **Pollution moderators:** Forests can absorb many toxic gases and can help in keeping the air pure. They have also been reported to absorb noise and thus help in preventing air and noise pollution.

■ OVER EXPLOITATION OF FORESTS

Since time immemorial, humans have depended heavily on forests for food, medicine, shelter, wood and fuel. With growing civilization the demands for raw material like timber, pulp, minerals, fuel wood etc. shooted up resulting in large scale logging, mining, road-building and clearing of forests. Our forests contribute substantially to the national economy. The international timber trade alone is worth over US $ 40 billion per year. Excessive use of fuel wood and charcoal, expansion of urban, agricultural and industrial areas and overgrazing have together led to over-exploitation of our forests leading to their rapid degradation.

■ DEFORESTATION

The total forest area of the world in 1900 was estimated to be 7,000 million hectares which was reduced to 2890 million ha in 1977 and fell down to just 2,300 million ha by 2000. Deforestation rate is relatively less in temperate countries, but it is very alarming in tropical countries where it is as high as 40-70 percent and at the present rate it is est.- mated that in the next 60 years we would lose more than 90 percent of our tropical forests.

The forested area in India seems to have stabilized since 1982 with about 0.04% decline annually between 1982-90. FAO (1983) estimated that about 1.44 m ha of land was brought under forestation during this period leading to stabilization. As per FAO estimates, the

Major Causes of Deforestation

(¿) Shifting cn1tiration: There are an estimated 300 million people living as shifting cultivators who practice slash and burn agriculture and are supposed to clear more than 7 lakh ha of forests for shifting cultivation annually. En Endia, we have this practice in North- East and to some extent in Andhra Pradesh, Bihar and M.P which contribute to nearly half of the forest clearing annually.

(¿¿) Fne1 reqnirements: Encreasing demands for fuel wood by the growing population in Endia alone has shooted up to 300-700 million tons in 2001 as compared to just 67 million tons during independence, thereby increasing the pressure on forests.

(¿¿¿) Raw materia1s for indnstria1 nse: Wood for making boxes, furniture, railway-sleepers, plywood, match-boxes, pulp for paper in- dustry etc. have exerted tremendous pressure on forests. Plywood is in great demand for packing tea for Tea industry of Assam while fir tree wood is exploited greatly for packing apples in J&K.

(¿v) Dere1opment projects: Massive destruction of forests occur for various development projects like

hydroelectric projects, big dams, road construction, mining etc.

(v) Growing food needs: En developing countries this is the main reason for deforestation. To meet the demands of rapidly growing population, agricultural lands and settlements are created permanently by clearing forests.

(v¿) Orergrazing: The poor in the tropics mainly rely on wood as a source of fuel leading to loss of tree cover and the cleared lands are turned into the grazing lands. Overgrazing by the cattle leads to fur- ther degradation of these lands.

Major Consequences of Deforestation

Deforestation has far reaching consequences, which may be outlined as follows:

(¿) Et threatens the existence of many wild life species due to destruction of their natural habitat.

(¿¿) Biodiversity is lost and along with that genetic diversity is eroded.

(¿¿¿) Hydrological cycle gets affected, thereby influencing rainfall. (¿v) Problems of soil erosion and loss of soil fertility increase.

(v) En hilly areas it often leads to landslides.

Major Activities in Forests

Timber Extraction: Logging for valuable timber, such as teak and Mahogany not only involves a few large trees per hectare but about a dozen more trees since they are strongly interlocked with each other by vines etc. Also road construction for making approach to the trees causes further damage to the forests.

Mining: Mining operations for extracting minerals and fossil fuels like coal often involves vast forest areas. Mining from shallow deposits is done by snrface mining while that from deep deposits is done by snb-snrface mining. More than 80,000 ha of land of the country is presently under the stress of mining activities. Mining and its associated activities require removal of vegetation along with underlying soil mantle and overlying rock masses. This results in defacing the topography and destruction of the landscape in the area.

Large scale deforestation has been reported in Mussorie and Dehradun valley due to indiscriminate mining of various minerals over a length of about 40 Km. The forested area has declined at an average rate of 33% and the increase in non-forest area due to mining activities has resulted in relatively unstable zones leading to landslides.

Endiscriminate mining in forests of Goa since 1961 has destroyed more than 70,000 ha of forest land. Coal mining in Jharia, Raniganj and Singrauli areas have caused extensive deforestation in Jharkhand. Mining of magnesite and soap- stones have destroyed 14 ha of forest in the hill slopes at Khirakot, Kosi valley, Almora. Mining of radioactive minerals in Kerala, Tamilnadu and Karnataka are posing similar threats of deforestation. The rich forests of Western Ghats are also facing the same threat due to mining projects for excavation of copper, chromite, bauxite and magnetite.

■ DAMS AND THEIR EFFECTS ON FORESTS AND PEOPLE

Big dams and river valley projects have multi-purpose uses and have been referred to as "Temples o/ modern Znd¿a". However, these dams are also responsible for the destruction of vast areas of forests. Endia has more than 1770 large dams, the maximum being in the state of Maharashtra (more then 600), followed by Gujarat (more then 270) and Madhya Pradesh (130). The highest one is Tehr¿ dam, on river Bhagirathi

in Uttaranchal and the largest in terms of capacity is Bhakra dam on river Satluj in H.P. Big dams have been in sharp focus of various environmental groups all over the world which is mainly because of several ecological problems including deforestation and socio-economic problems related to tribal or native people associated with them. The hydroelectric project was one of the first such projects situated in the tropical rain forest area of Western Ghats which attracted much concern of the people.

For building big dams, large scale devastation of forests takes place which breaks the natural ecological balance of the region. Floods, droughts and landslides become more prevalent in such areas. Forests are the repositories of invaluable gifts of nature in the form of biodiversity and by destroying them (particularly, the tropical rain for- ests) we are going to lose these species even before knowing them. These species could be having marvelous economic or medicinal value and deforestation results in loss of this storehouse of species which have evolved over millions of years in a single stroke.

Sardar Sarorar Dam (Uprooted Forests And Triba1s): A case stndy

The dam is situated on river Narmada and is spread over three states of Gujarat, Maharashtra and Madhya Pradesh. Although the project is aimed at providing irrigation water, drinking water and electricity to the three states, the environmental impacts of the project have raised challenging questions.

A total of 1,44,731 ha of land will be submerged by the dam, out of which 76,747 ha is forest land. A total of 773 villages are to be submerged by the Narmada Dam.

Submergence of about 40,000 ha of forest under Narmada Sagar, 13,800 ha under Sardar Sarovar and 2,700 ha under Omkareshwar would further create pressure on remaining forest areas in adjoining areas. Submergence area is very rich in wildlife e.g. tigers, panthers, bears, wolves, pangolins, hyenas, jackals, flying squirrels, antelopes, black bucks, chinkara, marsh crocodiles, turtles etc. Many of these species are listed in schedule E & EE of Wildlife Protection Act, 1972. Thus massive loss of these wildlife species is apprehended due to the devastation of the forest under the project.

As per the estimates of the Enstitute of Urban Affairs, New Delhi, the Narmada valley project will lead to eventual displacement of more than one million people, which is probably the largest rehabilitation issue ever encountered as per the World Bank.

Uprooting of the tribals and their forced shifting in far-flung areas may not be easily adjusted to. Besides serious economic deprivation, the displacement will affect the tribal peoples[3] culture, their beliefs, myths and rituals, festivals, songs and dances, all closely associated with the hills, forest and streams. Most of these tribals belong to poor, unprivileged schedule castes and tribes who are being uprooted from a place where they have lived for generations. The displaced persons have to undergo hardship and distress for the sake of development and prosperity of a larger section of the society. Et is therefore the duty of the project proponents and government to pay maximum attention for proper rehabilitation of the displaced tribals.

2.1 WATER RESOURCES

Water is an indispensable natural resource on this earth on which all life depends. About 97% of the earth³s surface is covered by water and most of the animals and plants have 60-67% water in their body.

Water is characterized by certain unique features which make it a marvellous resource:

(¿) Et exists as a liquid over a wide range of temperature i.e. from 0° to100°C.

(¿¿) Et has the highest specific heat, due to which it warms up and cools down very slowly without causing shocks of tempera- ture jerks to the aquatic life.

(¿¿¿) Et has a high latent heat of vaporization Hence, it takes a huge amount of energy for getting vaporized. That³s why it produces a cooling effect as it evaporates.

(¿v) Et is an excellent solvent for several nutrients. Thus, it can serve as a very good carrier of nutrients, including oxygen, which are essential for life. But, it can also easily dissolve various pollutants and become a carrier of pathogenic microorganisms.

(v) Due to high surface tension and cohesion it can easily rise through great heights through the trunk even in the tallest of the trees like Seguo¿a.

(v¿) Et has an anamolous expansion behaviour i.e. as it freezes, it expands instead of contracting and thus becomes lighter. Et is because of this property that even in extreme cold, the lakes freeze only on the surface. Being lighter the ice keeps floating, whereas the bottom waters remain at a higher temperature and therefore, can sustain aquatic organisms even in extreme cold.

The water we use keeps on cycling endlessly through the environment, which we call as Hydro1ogica1 Cyc1e. We have enormous resources of water on the earth amounting to about 1404 million Km^3. The water from various moist surfaces evaporates and falls again on the earth in the form of rain or snow and passes through living organisms and ultimately returns to the oceans. Every year about 1.4 inch thick layer of water evaporates from the oceans, more than 90% of which returns to the oceans through the hydrological cycle. Solar energy drives the water cycle by evaporating it from various water bodies, which subsequently return through rainfall or snow. Plants too play a very important role by absorbing the groundwater from the soil and releasing it into the atmosphere by the process of transpiration.

Global distribution of water resources is quite uneven depending upon several geographic factors. Tropical rain forest areas receive maximum rainfall while the major world deserts occur in zones of dry, descending air (20-40° N and S) and receive very little rainfall.

■ WATER USE AND OVER-EXPLOITATION

Due to its unique properties water is of multiple uses for all living organisms. Water is absolutely essential for life. Most of the life processes take place in water contained in the body. Uptake of nutrients, their distribution in the body, regulation of temperature, and removal of wastes are all mediated through water.

Human beings depend on water for almost every developmental activity. Water is used for drinking, irrigation, transportation, washing and waste disposal for industries and used as a coolant for thermal power plants. Water shapes the earth³s surface and regulates our climate.

Nater nse by humans is of two types: water withdrawa1: taking water from groundwater or surface water resource and water consnmption: the water which is taken up but not returned for reuse. Globally, only about 60 percent of the water withdrawn is consumed due to loss through evaporation.

With increasing human population and rapid development, the world water withdrawal demands have

increased many folds and a large proportion of the water withdrawn is polluted due to anthropogenic activities. On a global average 70 percent of the water withdrawn is used for agriculture. En Endia, we use 93% of water in agricultural sector while in a country like Kuwait, which is water-poor, only 4% is used for watering the crops. About 27% of water on global average is used in industry, which again varies from a high of 70% in European countries to as low as 7% in less developed countries. Per capita use of water shows wide variations. En USA, an average family of 4 consumes more than 1000 M^3 of water per year, which is many times more than that in most developing countries.

Water: A Precious Natural Resource

Although water is very abundant on this earth, yet it is very precious. Out of the total water reserves of the world, about 97% is salty water (marine) and only 3% is fresh water. Even this small fraction of fresh water is not available to us as most of it is locked up in polar ice caps and just 0.003% is readily available to us in the form of groundwater and surface water.

Overuse of groundwater for drinking, irrigation and domestic pur- poses has resulted in rapid depletion of groundwater in various regions leading to lowering of water table and drying of wells. Pollution of many of the groundwater aquifers has made many of these wells unfit for consumption.

Rivers and streams have long been used for discharging the wastes. Most of the civilizations have grown and flourished on the banks of rivers, but unfortunately, growth in turn, has been responsible for pollution of the rivers.

As per the United Nations estimates (2002), at least 101 billion people do not even have access to safe drinking water and 2.4 billion do not have adequate sanitation facilities. Encreasing population and expanding development would further increase the demands for wastes. Et is estimated that by 2024, two-thirds of the world population would be suffering from acute water shortage.

Groundwater

About 9.86% of the total fresh water resources is in the form of groundwater and it is about 37-70 times that of surface water supplies. Till some time back groundwater was considered to be very pure. However, of late, even groundwater aquifers have been found to be contaminated by leachates from sanitary landfills etc.

A layer of sediment or rock that is highly permeable and contains water is called an aqnifer. Layers of sand and gravel are good aquifers while clay and crystalline rocks (like granite) are not since they have low permeability. Aquifers may be of two types:

Unconfined aqnifers which are overlaid by permeable earth materials and they are recharged by water seeping down from above in the form of rainfall and snow melt.

Confined aqnifers which are sandwitched between two impermeable layers of rock or sediments and are recharged only in those areas where the aquifer intersects the land surface. Sometimes the recharged area is hundreds of kilometers away from the location of the well. Fig 2.2.1 shows the groundwater system. Groundwater is not static, it moves, though at a very slow rate of about a meter or so in a year.

Effects of Groundwater Usage

(¿) Snbsidence: When groundwater withdrawal is more than its recharge rate, the sediments in the aquifer get compacted, a phenomenon known as ground su&s¿dence. Huge economic losses may occur due to this phenomenon because it results in the sinking of overlying land surface. The common problems associated with it include structural damage in buildings, fracture in pipes, reversing the flow of sewers and canals and tidal flooding.

(¿¿) Lowering of water tab1e: Mining of groundwater is done extensively in arid and semi-arid regions for irrigating crop fields. However, it is not advisable to do excessive mining as it would cause a sharp decline in future agricultural production, due to lowering of water table.

(¿¿¿) Nater 1ogging: When excessive irrigation is done with brackish water it raises the water table gradually leading to water-logging and salinity problems.

Surface Water

The water coming through precipitation (rainfall, snow) when does not percolate down into the ground or does not return to the atmos- phere as evaporation or transpiration loss, assumes the form of streams, lakes, ponds, wetlands or artificial reservoirs known as surface water. The surface water is largely used for irrigation, industrial use, public water supply, navigation etc. A country³s economy is largely depend- ent upon its rivers.

Nater rich rs. Nater poor conntries

The top ten water rich countries are Eceland, Surinam, Guyana, Papua New Guinea, Gabon, Solomon Eslands, Canada, Norway, Panama, and Brazil lying in the far north and have low evaporation losses.

The water poor countries include Kuwait, Egypt, United Arab Emirates, Malta, Jordon, Saudi Arabia, Singapore, Maldovia, Esrael and Oman, lying in the desert belt at about 17° to 27° Latitude and some of them like Malta and Singapore are densely populated areas resulting in low per capita water.

■ FLOODS

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

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

Floods have been regular features of some parts of Endia and Bangladesh causing huge economic loss as well as loss of life. People of Bangladesh are accustomed to moderate flooding during monsoon and they

utilize the flood water for raising paddy. But, severe floods like that in 1970, 1988 and 1991 resulting from excessive Himalayan runoff and storms, had very disastrous consequences causing massive deaths and damages. En 1970, about one million people were drowned while 1,40,000 people died in 1991. Networking of rivers is being proposed at national level to deal with the problems of floods.

■ DROUGHTS

There are about 80 countries in the world, lying in the arid and semi- arid regions that experience frequent spells of droughts, very often extending up to year long duration. Nhen annna1 rainfa11 is be1ow norma1 and 1ess than eraporation, dronght conditions are created. Eronically, these drought- hit areas are often having a high population growth which leads to poor land use and makes the situation worse.

Anthropogenic canses: Drought is a meteorological phenomenon, but due to several anthropogenic causes like over grazing, deforestation, mining etc. there is spreading of the deserts tending to convert more areas to drought affected areas. En the last twenty years, Endia has experienced more and more desertification, thereby increasing the vulnerability of larger parts of the country to droughts.

Erroneous and intensive cropping pattern and increased exploitation of scarce water resources through well or canal irrigation to get high productivity has converted drought - prone areas into desertified ones. En Maharashtra there has been no recovery from drought for the last 30 years due to over-exploitation of water by sugarcane crop which has high water demands.

Remedia1 measnres: Endigenous knowledge in control of drought and desertification can be very useful for dealing with the problem. Carefully selected mixed cropping help optimize production and minimize the risks of crop failures. Social Forestry and Wasteland development can prove quite effective to fight the problem, but it should be based on proper understanding of ecological requirements and natural process, otherwise it may even boomrang. The Kolar district of Karnataka is one of the leaders in Social Forestry with World Bank Aid, but all its 11 talukas suffer from drought. Et is because the tree used for plantation here was Zucalyp5us which is now known to lower the water table because of its very high transpiration rate.

■ CONFLICTS OVER WATER

Endispensability of water and its unequal distribution has often led to inter-state or international disputes. Essues related to sharing of river water have been largely affecting our farmers and also shaking our governments. Some major water conflicts are discussed here.

- Nater conf1ict in the Midd1e East: Three river basins, namely the Jordan, the Tigris-Euphrates and the Nile are the shared water resources for Middle East countries. Ethiopia controls the head waters of 80% of Nile³s flow and plans to increase it.

Sudan too is trying to divert more water. This would badly affect Egypt, which is a desert, except for a thin strip of irrigated cropland along the river Nile and its delta.

The population of Egypt is likely to double in the next 20 years, thereby increasing its water crisis. Likewise there is a fierce battle for water among Jordan, Syria and Esrael for the Jordan River water share.

Turkey has abundant water and plans to build 22 dams on Tigris-Euphrates for Hydroelectric power

generation. But, it would drastically reduce the flow of water to Syria and Eraq, lying downstream. Turkey dreams to become the region³s water Super power. Et plans to transport and sell water to starved Saudi Arabia, Kuwait, Syria, Esrael and Jordan. Probably, the next war in the Middle East would be fought over water and not oil.

- The rndns Nater Treaty: The Endus, one of the mightiest rivers is dying a slow death due to dams and barragesthat have been built higher up on the river. The Sukkur barrage (1932), Ghulam Mohamad Barrage at Kotri (1978) and Tarbela and Chasma Dams on Jhelum, a tributary of Endus haveresulted in severe shrinking of the Endus delta. En 1960, the Endus water treaty was established vide which Endus, the Jhelum and the Chenab were allocated to Pakistan and the Satluj, the Ravi and the Beas were allocated to Endia. Being the riparian state, Endia has pre-emptive right to construct barrages across all these rivers in Endian territory. However, the treaty requires that the three rivers allocated to Pakistan may be used for non~consump5¿ve purposes by Endia i.e. without changing its flow and quality. With improving political relations between the two countries it is desirable to work out techno-economic details and go for an integrated development of the river basin in a sustainable manner.

- The Canrery water dispnte: Out of Endia³s 18 major rivers, 17 are shared between different states. En all these cases, there are intense conflicts over these resources which hardly seem to resolve. The Cauvery river water is a bone of contention between Tamilnadu and Karnataka and the fighting is almost hundred years old. Tamilnadu, occupying the downstream region of the river wants water-use regulated in the upstream. Whereas, the upstream state Karnataka refuses to do so and claims its primacy over the river as upstream user. The river water is almost fully utilized and both the states have increasing demands for agriculture and industry. The consumption is more in Tamilnadu than Karnataka where the catchment area is more rocky. On June 2,1990, the Cauvery WaterDispute Tribunal was set up which through an interim award directed Karnataka to ensure that 207 TMCF of water was made available in Tamil Nadu³s Mettur dam every year, till a settlement was reached. En 1991-92 due to good monsoon, there was no dispute due to good stock of water in Mettur, but in 1997, the situation turned into a crisis due to delayed rains and an expert Committee was set up to look into the matter which found that there was a complex cropping pattern in Cauvery basin. Sam&ra paddy in winter, Xurva¿ paddy in summer and some cash crops demanded intensive water, thus aggravating the water crisis. Proper selection of crop varieties, optimum use of water, better rationing, rational sharing patterns, and pricing of water are suggested as some measures to solve the problem.
- The Sat1nj-Yamnna 1ink (SYL) cana1 dispnte: The issue of sharing the Ravi-Beas waters and SYL issue between Punjab and Haryana is being discussed time and again and the case is in the Supreme Court. The Eradi Tribunal (1987) based the allocation of water on the basis of the time-inflow data of 20 years (1960-80), according to which 17.17 MAF (million acre feet) water was available. However, now it is argued by Punjab that in the last 17 years there has been consistent decline reducing the quantity to 14.34 MAF. The Supreme Court on January 17, 2002 directed Punjab to complete and commission the SYL within a year, failing which the Center was told to complete it. However, two years have passed, but neither the SYL has been completed nor the conflict over sharing of Ravi- Beas water is resolved.

The conflict is that Punjab being the riparian state for Beas, Ravi and Satluj stakes its claim, Haryana has faced acute shortage of water after it became a state in 1966 and has been trying to help it out by signing an MOU (Memorandum of understanding) with UP, Rajasthan and Delhi for allocation of Yamuna waters. The Yamuna basin covers the state of Haryana while the Endus basin coversPunjab.

The conflict revolving around sharing of river water needs to be tackled with greater understanding and

objectivity.

Traditional Water Management System

En Endia, even today, there are several villages where water management is done not by the Errigation Department, but by local managers. En south Endia, a neer#atti manages the traditional tanks very efficiently based on his/her knowledge of the terrain, drainage and irrigation needs. They usually give preference to the tail end fields and decide per capita allocation of water based on the stock of available water in the tank and crop needs. En Maharashtra, the water mangers are called 2avaldars or jag2yas who manage and resolve conflicts by overseeing the water channels from main canal to the distributory canals. En Ladakh, the water manager is known as c2ur¢un who has got complete charge with full powers over allocation of available water. The major source of water is melt water from glaciers and snow supplementary by water from springs and marshes. The water is distributed to different fields through an intricate network of earthen channels.

En traditional water management, innovative arrangements ensure equitable distribution of water, which are democratically implemented. The 'gram-sabhas³ approve these plans publicly. While water disputes between states and nations often assume battle like situations, our traditional water managers in villages prove to be quite effective.

■ **BIG DAMS- BENEFITS AND PROBLEMS Benefits**

River valley projects with big dams have usually been considered to
play a key role in the development process due to their multiple uses. Endia has the distinction of having the largest number of river-valley projects. These dams are often regarded as a symbol of national development. The tribals living in the area pin big hopes on these projects as they aim at providing employment and raising the standard and quality of life. The dams have tremendous potential for economic upliftment and growth. They can help in checking floods and famines, generate electricity and reduce water and power shortage, provide irrigation water to lower areas, provide drinking water in remote areas and promote navigation, fishery etc.

Environmental Problems

The environmental impacts of big-dams are also too many due to which very often the big dams become a subject of controversy. The impacts can be at the upstream as well as downstream levels.

(A) The upstream problems include the following: (¿) Displacement of tribal people (¿¿) Loss of forests, flora and fauna

(¿¿¿) Changes in fisheries and the spawning grounds (¿v) Siltation and sedimentation of reservoirs

(v) Loss of non-forest land

(v¿) Stagnation and waterlogging near reservoir

(v¿¿) Breeding of vectors and spread of vector-borne diseases (v¿¿¿) Reservoir induced seismicity (RES) causing earthquakes (¿x) Growth of aquatic weeds.

(x) Microclimatic changes.

(B) The downstream impacts include the following:

(¿) Water logging and salinity due to over irrigation (¿¿) Micro-climatic changes

(¿¿¿) Reduced water flow and silt deposition in river (¿v) Flash floods

(v) Salt water intrusion at river mouth

(v¿) Loss of land fertility along the river since the sediments carry- ing nutrients get deposited in the reservoir

(v¿¿) Outbreak of vector-borne diseases like malaria

Thus, although dams are built to serve the society with multiple uses, but it has several serious side-effects. That is why now there is a shift towards construction of small dams or mini-hydel projects.

2.2 MINERAL RESOURCES

Minerals are naturally occurring, inorganic, crystalline solids having a definite chemical composition and characteristic physical properties. There are thousands of minerals occurring in different parts of the world. However, most of the rocks, we see everyday are just composed of a few common minerals like quartz, feldspar, biotite, dolomite, calcite, laterite etc. These minerals, in turn, are composed of some elements like silicon, oxygen, iron, magnesium, calcium, aluminium etc.

■ USES AND EXPLOITATION

Minerals find use in a large number of ways in everyday use in domestic, agricultural, industrial and commercial sectors and thus form a very important part of any nation³s economy. The main uses of minerals are as follows:

(¿) Development of industrial plants and machinery. (¿¿) Generation of energy e.g. coal, lignite, uranium. (¿¿¿) Construction, housing, settlements.

(¿v) Defence equipments-weapons, armaments.

(v) Transportation means.

(v¿) Communication- telephone wires, cables, electronic devices. (v¿¿) Medicinal system- particularly in Ayurvedic System.

(v¿¿¿) Formation of alloys for various purposes (e.g. phosphorite). (¿x) Agriculture–as fertilizers, seed dressings and fungicides (e.g.
zineb containing zinc, Maneb-containing manganese etc.).

(x) Jewellery–e.g. Gold, silver, platinum, diamond.

Based on their properties, minerals are basically of two types:

(¿) Non metallic minerals e.g. graphite, diamond, quartz, feldspar. (¿¿) Metallic minerals e.g. Bauxite, laterite, haematite etc.

Use of metals by human beings has been so extensive since the very beginning of human civilization that two of the major epochs of human history are named after them as Bronze Age and Eron Age. The reserves of metals and the technical know-how to extract them have been the key elements in determining the economy and political power of nations. Out of the various metals, the one used in maximum quantity is Eron and steel (740 million metric tons annually) followed by manganese, copper, chromium, aluminium and Nickel.

Distribution and uses of some of the major metallic and non- metallic minerals are given in Tables 2.3.1 and 2.3.2.

Tab1e 2.3.1. Major reserres and important nses of some of the major meta1s

Meta1	Major Nor1d Reserres	Major Uses
Aluminium	Australia, Guinea	Packaging food items, transpor-tation, utensils, electronics

	, Jamaica	
Chromium	CES, South Africa	For making high strength steel alloys, En textile/tanning industries
Copper	U.S.A., Canada, CES	Electric and electronic goods, building, construction, vessels

	, Chile, Zambia	
Eron	CES, South America, Canada, U.S	Heavy machinery, steel produc-tion transportation means

	. A .	
Lead	North America, U.S.A., CES	Leaded gasoline, Car batteries, paints, ammunition
Manganese	South Afric	For making high strength, heat-resistant steel alloys
Plat	Sout	Use in automobi

inum group	h Africa, CES	les, catalytic converters, electronics, medical uses.
Gold	South Afric	Ornaments, medical use, elec-tronic use, use in aerospace
Silver	Canada, South Afric	Photography, electronics jewellery

	a, Mexico	
Nickel	CES, Canada, New Caledonia	Chemical industry, steel alloys

Tab1e 2.3.2. Major nses of some non-meta11ic minera1s

Non-met	Major Uses

a 1 M i n e r a 1	
S i l i c a t e m i n e r a l s	Sand and gravel for construction, bricks, paving etc.
L i m e s t o n e	Used for concrete, building stone, used in agriculture for neutralizing acid soils, used in cement industry
G y p s u m	Used in plaster wall-board, in agriculture
P o t	Used as fertilizers

ash, phosphorite	
Sulphur pyrites	Used in medicine, car battery, industry.

Et is evident from the Tables that the CES countries (The Com- monwealth of Endependent States ¿.e. 12 repubics of former USSR), the United States of America, Canada, South Africa and Australia are having the major world reserves of most of the metallic minerals. Due to huge mineral and energy resources, the USA became the richest and the most powerful nation in the world in even less than 200 years. Ja- pan too needs a mention here, as there are virtually no metal reserves, coal, oil and timber resources in Japan and it is totally dependent on other countries for its resources. But, it has developed energy efficient technologies to upgrade these resources to high quality finished prod- ucts to sustain its economy.

Minerals are sometimes classified as Critica1 and Strategic. Critica1 minera1s are essential for the economy of a nation e.g.
iron, aluminium, copper, gold etc.

Strategic minera1s are those required for the defence of a country
e.g. Manganese, cobalt, platinum, chromium etc.

Some Major Minerals of India

(a) Energy generating minera1s

Coal and lignite: West Bengal, Jharkhand, Orissa, M.P., A.P. Uranium (Pitchblende or Uranite ore): Jharkhand, Andhra Pradesh(Nellore, Nalgonda), Meghalaya, Rajasthan (Ajmer).

(&) Other commercia11y nsed minera1s

Aluminium (Baux¿5e ore): Jharkhand, West Bengal, Maharashtra, M.P., Tamilnadu.

Sron (haema5¿5e and magne5¿5e ore): Jharkhand, Orissa, M.P., A.P., Tamilnadu, Karnataka, Maharashtra and Goa.

Co¢¢er (✓opper 9yr¿5es): Rajasthan (Khetri), Bihar, Jharkhand, Karnataka, M.P., West Bengal, Andhra Pradesh and Uttaranchal.

■ ENVIRONMENTAL IMPACTS OF MINERAL EXTRACTION AND USE

The issue related to the limits of the mineral resources in our earth³s crust or in the ocean is not so significant. More important environ- mental concern arises from the impacts of extraction and processing of these minerals during mining, smelting etc.

rndian Scenario: Endia is the producer of 84 minerals the annual value of which is about Rs. 70,000 crore. At least six major mines need a mention here which are known for causing severe problems:

(¿) Jadngnda Uraninm Mine, Jharkhand—exposing local people to radioactive hazards.

(¿¿) Jharia coa1 mines, Jharkhand—underground fire leading to land subsidence and forced displacement of people.

(¿¿¿) Snkinda chromite mines, Orissa—seeping of hexavalent chromium into river posing serious health hazard, Cr^{6+} being highly toxic and carcinogenic.

(¿v) Kndremnkh iron ore mine, Karnataka—causing river pollution and threat to biodiversity.

(v) East coast Banxite mine, Orissa—Land encroachment and issue of rehabilitation unsettled.

(v¿) North-Eastern Coa1 Fie1ds, Assam—Very high sulphur contamination of groundwater.

rmpacts of mining: Mining is done to extract minerals (or fossil fuels) from deep deposits in soil by using snb-snrface mining or from shallow deposits by snrface mining. The former method is more destructive, dangerous and expensive including risks of occupational hazards and accidents.

Surface mining can make use of any of the following three types:

(a) Open~p¿5 m¿n¿ng in which machines dig holes and remove the ores (e.g. copper, iron, gravel, limestone, sandstone, marble, granite).

(&) Dredg¿ng in which chained buckets and draglines are used which scrap up the minerals from under-water mineral deposits.

(c) S5r¿p m¿n¿ng in which the ore is stripped off by using bulldozers, power shovels and stripping wheels (e.g. phosphate rocks).

The environmental damage caused by mining activities are as follows:

(¿) Deregetation and defacing of 1andscape: The topsoil as well as the vegetation are removed from the mining area to get access to the deposit. While large scale deforestation or devegetation leads to several ecological losses as already discussed in the previous section, the landscape also gets badly affected. The huge quantities of debris and tailings alongwith big scars and disruptions spoil the aesthetic value of the region and make it prone to soil erosion.

(¿¿) Snbsidence of 1and: This is mainly associated with underground mining. Subsidence of mining areas often results in tilting of buildings, cracks in houses, buckling of roads,

bending of rail tracks and leaking of gas from cracked pipe- lines leading to serious disasters.

(¿¿¿) Gronndwater contamination: Mining disturbs the natural hydrological processes and also pollutes the groundwater. Sulphur, usually present as an impurity in many ores is known to get converted into sulphuric acid through microbial action, thereby making the water acidic. Some heavy metals also get leached into the groundwater and contaminate it posing health hazards.

(¿v) Snrface water po11ntion: The acid mine drainage often con- taminates the nearby streams and lakes. The acidic water is detrimental to many forms of aquatic life. Sometimes radio- active substances like uranium also contaminate the water bodies through mine wastes and kill aquatic animals. Heavy metal pollution of water bodies near the mining areas is a common feature creating health hazards.

(v) Air po11ntion: En order to separate and purify the metal from other impurities in the ore, smelting is done which emits enormous quantities of air pollutants damaging the vegetation nearby and has serious environmental health impacts. The suspended particulate matter (SPM), SOx, soot, arsenic particles, cadmium, lead etc. shoot up in the atmosphere near the smelters and the public suffers from several health problems.

(v¿) Occnpationa1 Hea1th Hazards: Most of the miners suffer from various respiratory and skin diseases due to constant exposure to the suspended particulate matter and toxic substances. Miners working in different types of mines suffer from asbestosis, silicosis, black lung disease etc.

Remedia1 measnres: Safety of mine workers is usually not a priority subject of industry. Statistical data show that, on an average, there are 30 non-fatal but disabling accidents per ton of mineral produced and one death per 2.7 tons of mineral produced.

En order to minimize the adverse impacts of mining it is desirable to adopt eco-friendly mining technology. The low-grade ores can be better utilized by using microbia1-1eaching techniqne. The bacterium Th¿o&ac¿llus /errox¿dans has been successfully and economically used for extracting gold embedded in iron sulphide ore. The ores are inoculated with the desired strains of bacteria, which remove the impurities (like sulphur) and leave the pure mineral. This biological method is helpful from economic as well as environmental point of view.

Restoration of mined areas by re-vegetating them with appropri- ate plant species, stabilization of the mined lands, gradual restoration of flora, prevention of toxic drainage discharge and conforming to the standards of air emissions are essential for minimizing environmental impacts of mining.

CASE STUDrES

- Mining and qnarrying in Udaipnr

About 200 open cast mining and quarrying centers in Udaipur, about half of which are illegal are involved in stone mining including soapstone, building stone, rock phosphate and dolomite. The mines spread over 17,000 hectares in Udaipur have caused many adverse impacts on environment. About 170 tonnes of explosives are used per month in blasting. The overburden, washoff, discharge of mine water etc. pollute the water. The Maton mines have badly polluted the Ahar river. The hills around the mines are devoid of any vegetation except a few scattered patches and the hills are suffering from acute soil erosion. The waste water flows towards a big tank of "Bag Dara". Due to scarcity of water people are compelled to use this effluent for irrigation purpose.

The blasting activity has adversely affected the fauna and the animals like tiger, lion, deer and even hare, fox, wild cats and birds have disappeared from the mining area.

- Mining in Sariska Tiger Reserre in Arara11is

The Aravalli range is spread over about 692 km in the North-west Endia covering Gujarat, Rajasthan, Haryana and Delhi. The hill region is very rich in biodiversity as well as mineral resources. The Sariska tiger reserve has gentle slopy hills, vertical rocky valleys, flat plains as well as deep gorges. The reserve is very rich in wild life and has enormous mineral reserves like quartzite, Schists, marble and granite in abundance.

Mining operations within and around the Sariska Tiger reserve has left many areas permanently infertile and barren. The precious wild life is under serious threat. We must preserve the Aravalli series as a National Heritage and the Supreme Court on December 31st, 1991 has given a judgement in response to a Public Enterest Litigation of Tarun Bharat Sangh, an NGO wherein both Centre and State Government of Rajasthan have been directed to ensure that all mining activity within the park be stopped. More than 400 mines were shut immediately. But, still some illegal mining is in progress.

FOOD RESOURCES

We have thousands of edible plants and animals over the world out of which only about three dozen types constitute the major food of hu- mans. The main food resources include wheat, rice, maize, potato, barley, oats, cassava, sweet potato, sugarcane, pulses, sorghum, millet, about twenty or so common fruits and vegetables, milk, meat, fish and seafood. Amongst these rice, wheat and maize are the major grains, about 1700 million metric tons of which are grown each year, which is about half of all the agricultural crops. About 4 billion people in the developing countries have wheat and rice as their staple food.

Meat and milk are mainly consumed by more developed nations of North America, Europe and Japan who consume about 80% of the total. Fish and sea-food contribute about 70 million metric tons of high quality protein to the world³s diet. But there are indications that we have already surpassed sustainable harvests of fish from most of the world³s oceans.

The Food and Agriculture Organization (FAO) of United Na- tions estimated that on an average the minimum caloric intake on a global scale is 2,700 calories/day. People receiving less than 90% of these minimum dietary calories are called nndernonrished and if it is less than 80% they are said to be serions1y nndernonrished. Besides the minimum caloric intake we also need proteins, minerals etc. Defi- ciency or lack of nutrition often leads to ma1nntrition resulting in sev- eral diseases as shown in Table 2.4.1.

Tab1e 2.4.1. rmpacts of ma1nntrition

Deficiency	Hea1th Effect	No. of Cases	Deaths per year (in mi

			11ions)
Proteins and Calories	Stunted growth, Kwashiorkor, Marasmus	7701 million	17-20
E	A	3	0

ron	nemia	70 million	.77-1
Eodine	Goitre, Cretinism	170 million, 6 million	
Vitamin A	Blindness	6 million	

■ WORLD FOOD PROBLEMS

During the last 70 years world grain production has increased almost three times, thereby increasing per capita production by about 70%. But, at the same time population growth increased at such a rate in LDCs (Less developed countries) that it outstripped food production. Every year 40 million people (fifty percent of which are young children between 1 to 7 years) die of undernourishment and malnutrition. This means that every year our food ¢roblem is #illing as many ¢eo¢le as were #illed by t2e atomic bomb dro¢¢ed on Kiros2ima during World War SS. These startling statistical figures more than emphasize the need to increase our food production, equitably distribute it and also to control population growth.

rndian Scenario: Although Endia is the third largest producer of staple crops, an estimated 300 million Endians are still undernourished. Endia has only half as much 1and as USA, but it has nearly three times population to feed. Our food problems are directly related to popula- tion.

The Nor1d Food Snmmit, 1996 has set the target to reduce the number of undernourished to just half by 2017, which still means 410 million undernourished people on the earth.

■ IMPACTS OF OVERGRAZING AND AGRICULTURE

(A) Orergrazing

Livestock wealth plays a crucial role in the rural life of our country. Endia leads in live stock population in the world. The huge population of livestock needs to be fed and the grazing lands or pasture areas are not adequate. Very often we find that the live stock grazing on a particular piece of grassland or pasture surpass the carrying capacity. Carrying capacity of any system is the maximum population that can be supported by it on a sustainable basis. However, most often, the grazing pressure is so high that its carrying capacity is crossed and the sustainability of the grazing lands fails. Let us see what are the impacts of overgrazing.

rmpact of Orergrazing

(¿) Land Degradation: Overgrazing removes the vegetal cover over the soil and the exposed soil gets compacted due to which the operative soil depth declines. So the roots cannot go much deep into the soil and adequate soil moisture is not available. Organic recycling also declines in the ecosystem because not enough detritus or litter

remains on the soil to be decomposed. The humus content of the soil decreases and overgrazing leads to organically poor, dry, compacted soil. Due to trampling by cattle the soil loses infiltration capacity, which reduces percolation of water into the soil and as a result of this more water gets lost from the ecosystem along with surface run off. Thus over grazing leads to multiple actions resulting in loss of soil structure, hydraulic conductivity and soil fertility.

(¿¿) Soi1 Erosion: Due to overgrazing by cattle, the cover of veg- etation almost gets removed from the land. The soil becomes exposed and gets eroded by the action of strong wind, rainfall etc. The grass roots are very good binders of soil. When the grasses are removed, the soil becomes loose and susceptible to the action of wind and water.

(¿¿¿) Loss of nsefn1 species: Overgrazing adversely affects the composition of plant population and their regeneration capacity. The original grassland consists of good quality grasses and forbs with high nutritive value. When the livestock graze upon them heavily, even the root stocks which carry the reserve food for regeneration get destroyed. Now some other species appear in their place. These secondary species are hardier and are less nutritive in nature. Some livestock keep on overgrazing on these species also. Ultimately the nutritious, juicy fodder giving species like ✓enchrus, D¿chan5h¿um, 9an¿cum and He5eropogon etc. are replaced by unpalatable and sometimes thorny plants like 9ar5hen¿um, Lan5ana, Xan5h¿um etc. These species do not have a good capacity of binding the soil particles and, therefore, the soil becomes more prone to soil erosion.

As a result of overgrazing vast areas in Arunachal Pradesh and Meghalaya are getting invaded by thorny bushes, weeds etc. of low fodder value. Thus overgrazing makes the grazing land lose its regenerating capacity and once good quality pasture land gets converted into an ecosystem with poor quality thorny vegetation.

(B) Agricn1tnre

En the early years of human existence on this earth, man was just a hunter gatherer and was quite like other animal species. Some 10,000 to 12,000 years ago he took to agriculture by cultivating plants of his own choice. He used the practice of S1ash and bnrn cn1tiration or shifting cn1tiration, which is still prevalent in many tribal areas, as in the North East Hills of Endia. The type of agriculture practiced these days is very different from the traditional ones and their outputs in terms of yield as well as their impacts on the environment show lots of differences.

1. Traditiona1 agricn1tnre and its impacts: Et usually involves a small plot, simple tools, naturally available water, organic fertilizer and a mix of crops. Et is more near to natural conditions and usually it results in low production. Et is still practiced by about half the global population.

The main impacts of this type of agriculture are as follows:

(¿) Deforestation: The slash and burn of trees in forests to clear the land for cultivation and frequent shifting result in loss of forest cover.

(¿¿) Soi1 erosion: Clearing of forest cover exposes the soil to wind, rain and storms, thereby resulting in loss of top fertile layer of soil.

(¿¿¿) Dep1etion of nntrients: During slash and burn the organic matter in the soil gets destroyed and most of the nutrients are taken up by the crops within a short period, thus making the soil nutrient poor which makes the cultivators shift to another area.

2. Modern Agricn1tnre and its impacts: Et makes use of hybrid seeds of selected and single crop variety, high-tech equipments and lots of energy subsidies in the form of fertilizers, pesticides and irrigation water. The food production has increased tremendously, evidenced by "green revolution". However, it also gave rise to several problematic off-shoots as discussed below:

(¿) rmpacts re1ated to high yie1ding rarieties (HYV): The uses of HYVs encourage monoculture i.e. the same genotype is grown over vast areas. En case of an attack by some pathogen, there is total devas- tation of the crop by the disease due to exactly uniform conditions, which help in rapid spread of the disease.

(¿¿) Ferti1izer re1ated prob1ems:

(a) Micronntrient imba1ance: Most of the chemical fertilizers used in modern agriculture have nitrogen, phosphorus and potassium (N, P, K) which are essential macronutrients. Farm- ers usually use these fertilizers indiscriminately to boost up crop growth. Excessive use of fertilizers cause m¿cronu5r¿en5 ¿m&alance. For example, excessive fertilizer use in Punjab and Haryana has caused deficiency of the micronutrient zinc in the soils, which is affecting productivity of the soil.

(&) Nitrate Po11ntion: Nitrogenous fertilizers applied in the fields often leach deep into the soil and ultimately contaminate the ground water. The nitrates get concentrated in the water and when their concentration exceeds 27 mg/L, they become the cause of a serious health hazard called "B1ne Baby Syndrome" or methaemoglobinemia. This disease affects the

infants to the maximum extent causing even death. En Denmark, England, France, Germany and Netherlands this problem is quite prevalent. En Endia also, problem of nitrate pollution exists in many areas.

(c) Entrophication: Excessive use of N and P fertilizers in the agricultural fields leads to another problem, which is not related to the soil, but relates to water bodies like lakes. A large proportion of nitrogen and phosphorus used in crop fields is washed off and along with runoff water reach the water bodies causing over nourishment of the lakes, a process known as Entrophication (eu=more, trophic=nutrition). Due to eutrophication the lakes get invaded by algal blooms. These algal species grow very fast by rapidly using up the nutrients. They are often toxic and badly affect the food chain. The algal species quickly complete their life cycle and die thereby adding a lot of dead organic matter. The fishes are also killed and there is a lot of dead matter that starts getting decomposed. Oxygen is consumed in the process of decomposition and very soon the water gets depleted of dissolved oxygen. This further affects aquatic fauna and ultimately anaerobic conditions are created where only pathogenic anaerobic bacteria can survive. Thus, due to excessive use of fertilizers in the agricultural fields the lake ecosystem gets degraded. This shows how an unmindful action can have far reaching impacts.

(¿¿¿) Pesticide related prob1ems: Thousands of types of pesticides are used in agriculture. The first generation pesticides include chemicals like sulphur, arsenic, lead or mercury to kill the pests. DDT (Dichlorodiphenyl trichloroethane) whose insecticidal properties were discovered by Paul Mueller in 1939 belongs to the second generation pesticides. After 1940, a large number of synthetic pesticides came into use. Although these pesticides have gone a long way in protecting our crops from huge losses occurring due to pests, yet they have a number of side-effects, as discussed below:

(a) Creating resistance in pests and prodncing new pests: Some individuals of the pest species usually survive even after pesticide spray. The survivors give rise to highly resistant generations. About 20 species of pests are now known which have become immune to all types of pesticides and are known as "Snper pests".

(&) Death of non-target organisms: Many insecticides are broad spectrum poisons which not only kill the target species but also several non-target species that are useful to us.

(c) Bio1ogica1 magnification: Many of the pesticides are non- biodegradable and keep on accumulating in the food chain, a process called biological magnification. Since human beings occupy a high trophic level in the food chain, hence thwhich is very harmful.

(¿v) Nater Logging: Over irrigation of croplands by farmers for good growth of their crop usually leads to waterlogging. Enadequate drainage causes excess water to accumulate underground and gradually forms a continuous column with the water table. Under water-logged conditions, pore-spaces in the soil get fully drenched with water and the soil-air gets depleted. The water table rises while the roots of plants do not get adequate air for respiration. Mechanical strength of the soil declines, the crop plants get lodged and crop yield falls.

En Punjab and Haryana, extensive areas have become water-logged where adequate canal water supply or tube-well water encouraged the farmers to use it over-enthusiastically leading to water-logging problem.

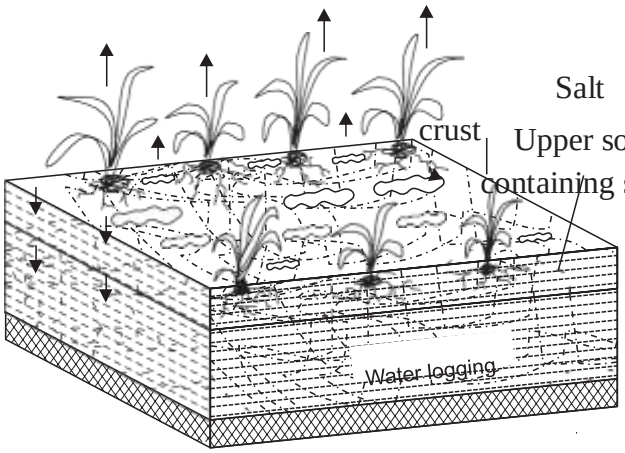
Preventing excessive irrigation, sub-surface drainage technology and bio-drainage with trees like Eucalyptus are some of the remedial measures to prevent water-logging.

(v) Sa1inity prob1em: At present one third of the total cultivable land area of the world is affected by salts. En Endia about seven million hectares of land are estimated to be salt—affected which may be saline or sodic. Saline soils are characterized by the accumulation of soluble salts like sodium chloride, sodium sulphate, calcium chloride, magnesium chloride etc. in the soil profile. Their electrical conductivity is more than 4 dS/m. Sodic soils have carbonates and bicarbonates of sodium, the pH usually exceeds 8.0 and the exchangeable sodium percentage (ESP) is more than 17%.

Canses: A Major cause of salinization of soil is excessive irrigation. About 20% of the world³s croplands receive irrigation with canal water or ground water which unlike rainwater often contains dissolved salts. Under dry climates, the water evaporates leaving behind salts in the upper soil profile (Fig. 2.4.1)

Thousands of hectares of land area in Haryana and Punjab are affected by soil salinity and alkalinity. Salinity causes stunted plant growth and lowers crop yield. Most of the crops cannot tolerate high salinity.

Evaporation and transpiration



Percolation of saline irrigation water

Less permeable clay layer

Salinization

- Addition of salts with saline irrigation water
- Evapo-transpiration leaves behind salts
- Salt-build up occurs in upper soil profile

Waterlogging

- Rain water and irrigation water percolate down
- Water table rises

Fig. 2.4.1. Salinization and water logging.

Remedy: The most common method for getting rid of salts is to flush them out by applying more good quality water to such soils. Another method is laying underground network of perforated drainage pipes for flushing out the salts slowly. This sub-surface drainage system has been tried in the experimental station of CSSRE at Sampla, Haryana. The Central Soil Salinity Research Enstitute (CSSRE) located in Karnal, Haryana has to its achievement the success story of conver ting Xar¿/a V¿ran village to Xar¿/a A&ad i.e. '/rom 5he &arren land 5o produc5¿ve land³ through its research applications.

CASE STUDIES

Sa1inity and water 1ogging in Pnnjab, Haryana and Rajasthan : The first alarming report of salt-affected wasteland formation in connection with irrigation practices came from Haryana (then Punjab) in 1878. Et was reported that several villages in Panipat, Rohtak and Delhi lying in command area of Western Yamuna Canal were suffering from destructive saline efflorescence. The "Reh Committee" in 1886 drew the attention of the government on some vital points showing a close relationship between irrigation, drainage and spread of "reh" and "usar" soils.

2.5. ENERGY RESOURCES

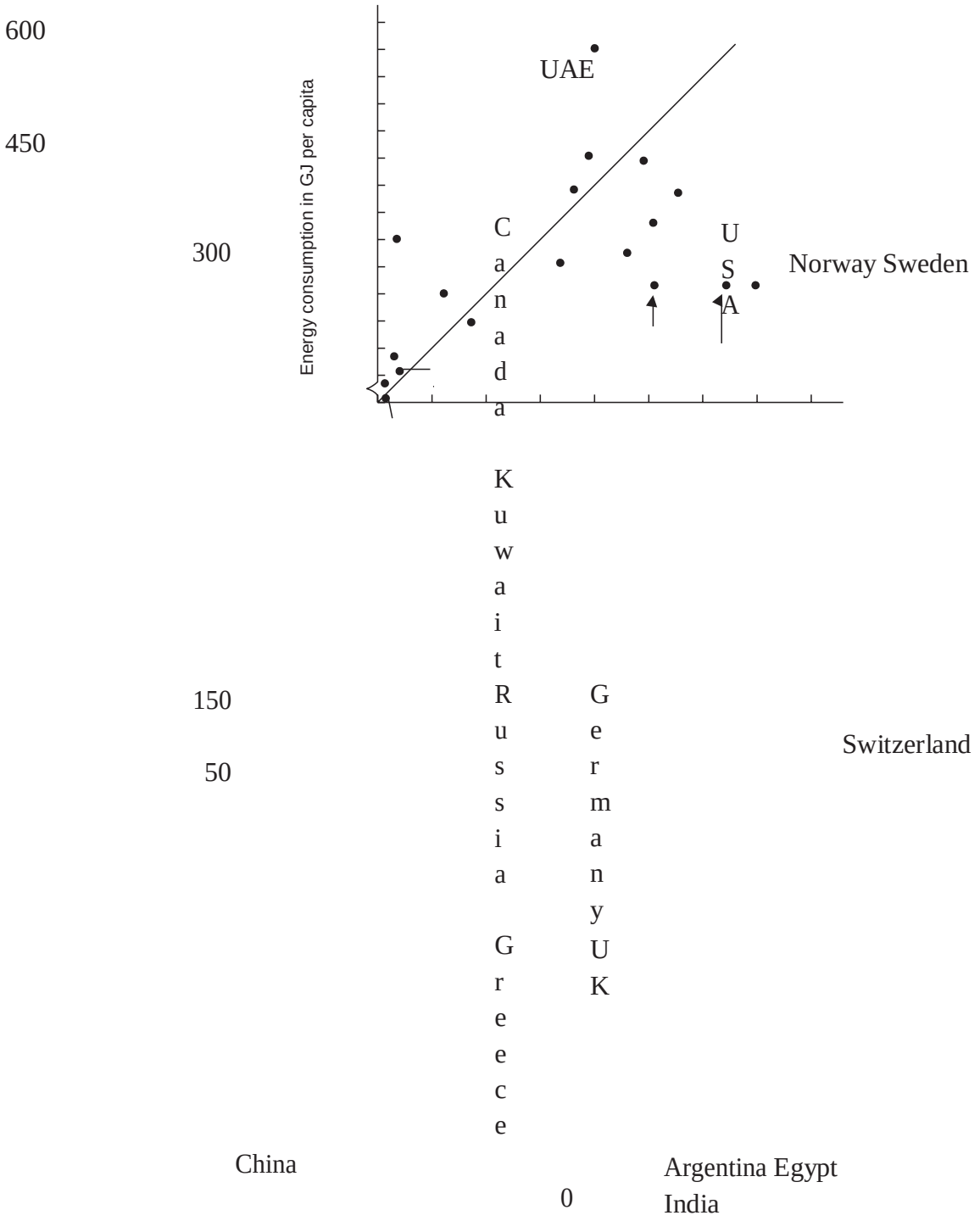
Energy consumption of a nation is usually considered as an index of its development. This is because almost all the developmental activities are directly or indirectly dependent upon energy. We find wide disparities in per capita energy use between the developed and the developing nations.

The first form of energy technology probably was the fire, which produced heat and the early man used it for cooking and heating purposes. Wind and hydropower have also been in use for the last 10,000 years. The invention of steam engines replaced the burning of wood by coal and coal was later replaced to a great extent by oil. En 1970³s due to Eranian revolution and Arab oil embargo the prices of oil shooted up. This ultimately led to exploration and use of several alternate sources of energy.

■ GROWING ENERGY NEEDS

Development in different sectors relies largely upon energy. Agriculture, industry, mining, transportation, lighting, cooling and heating in buildings all need energy. With the demands of growing population the world is facing further energy deficit. The fossil fuels like coal, oil and natural gas which at present are supplying 97% of the commercial energy of the world resources and are not going to last for many more

years. Our life style is changing very fast and from a simple way of life we are shifting to a luxurious life style. Ef you just look at the number of electric gadgets in your homes and the number of private cars and scooters in your locality you will realize that in the last few years they have multiplied many folds and all of them consume energy.



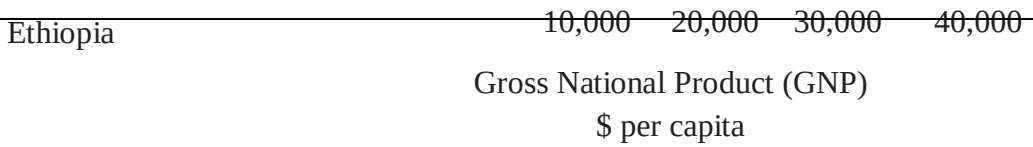


Fig. 2.5.1. Per capita energy use and GNP (Data from World Resources Institute, 1997)

■ RENEWABLE AND NON-RENEWABLE ENERGY SOURCES

A source of energy is one that can provide adequate amount of energy in a usable form over a long period of time. These sources can be of two types:

(1) Renewab1e Resonrces which can be generated continnons1y in natnre and are inexhanstib1e e.g. wood, solar energy, wind energy, tidal energy, hydropower, biomass energy, bio-fuels, geo-thermal energy and hydrogen. They are also known as non-conventional sources of energy and they can be used again and again in an endless manner.

(2) Non-renewab1e Resonrces which hare accnmn1ated in natnre orer a 1ong span of time and cannot be qnick1y rep1enished when exhansted e.g. coal, petroleum, natural gas and nuclear fuels like uranium and thorium.

Wood is a renewable resource as we can get new wood by growing a sapling into a tree within 17-20 years but it has taken millions of years for the formation of coal from trees and cannot be regenerated in our life time, hence coal is not renewable. We will now discuss various forms of renewable and non-renewable energy resource.

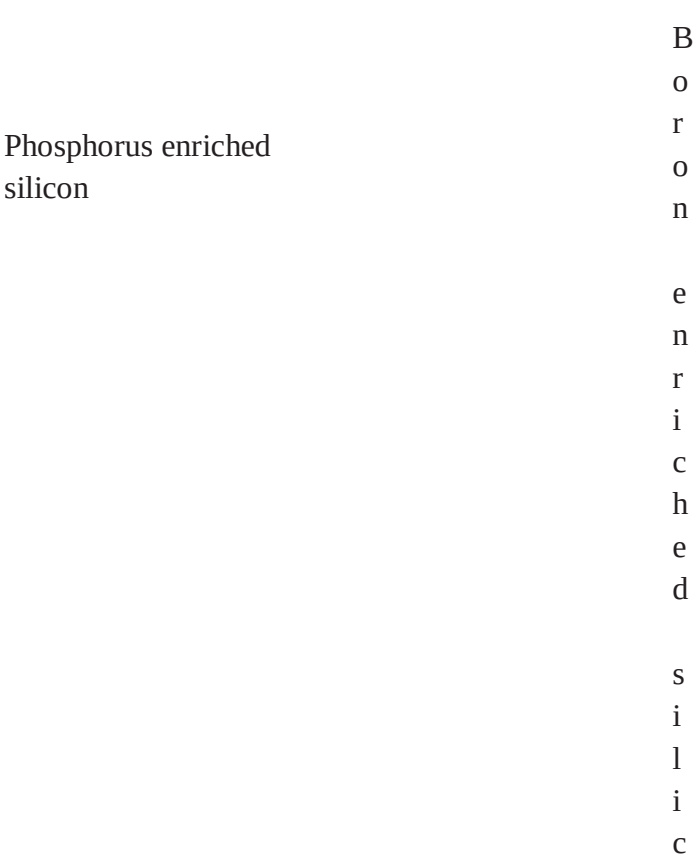
(a) Renewab1e Energy Resonrces

So1ar energy: Sun is the ultimate source of energy, directly or indirectly for all other forms of energy. The nuclear fusion reactions occurring inside the sun release enormous quantities of energy in the form of heat and light. The solar energy received by the near earth space is approximately 1.4 kilojoules/second/m^2 known as solar con- stant.

Traditionally, we have been using solar energy for drying clothes and food-grains, preservation of eatables and for obtaining salt from sea-water. Now we have several techniques for harnessing solar en- ergy. Some important solar energy harvesting devices are discussed here.

(¿) So1ar heat co11ectors: These can be passive or active in nature. Passive solar heat collectors are natural materials like stones, bricks etc. or material like glass which absorb heat during the day time and release it slowly at night. Active solar collectors pump a heat absorbing medium (air or water) through a small collector which is normally placed on the top of the building.

(¿¿) So1ar ce11s: They are also known as photovoltaic cells or PV cells. Solar cells are made of thin wafers of semi conductor materials like silicon and gallium. When solar radiations fall on them, a potential difference is produced which causes flow of electrons and produces electricity. Silicon can be obtained from silica or sand, which is abundantly available and inexpensive. By using gallium arsenide, cadmium sulphide or boron, efficiency of the PV cells can be improved. The potential difference produced by a single PV cell of 4 cm^2 size is about 0.4-0.7 volts and produces a current of 60 milli amperes. Fig. 2.7.2 (a) shows the structure of a solar cell.



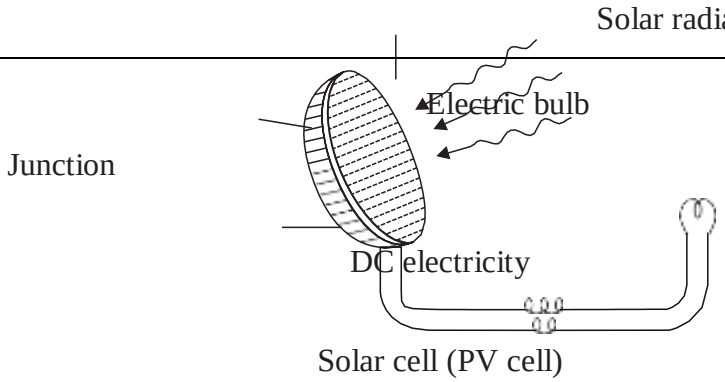


Fig. 2.5.2. (*a*) Solar cell.

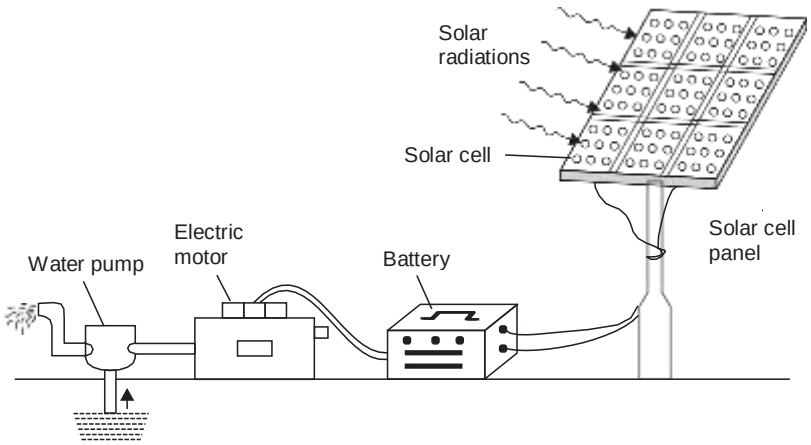


Fig. 2.5.2. (*b*) A solar pump run by electricity produced by solar cells.

A group of solar cells joined together in a definite pattern form a solar panel which can harness a large amount of solar energy and can produce electricity enough to run street-light, irrigation water pump etc. (Fig. 2.7.2).

Solar cells are widely used in calculators, electronic watches, street lighting, traffic signals, water pumps etc. They are also used in artifi- cial satellites for electricity generation. Solar cells are used for running radio and television also. They are more in use in remote areas where conventional electricity supply is a problem.

(¿¿¿) So1ar cooker: Solar cookers make use of solar heat by reflecting the solar radiations using a mirror directly on to a glass sheet

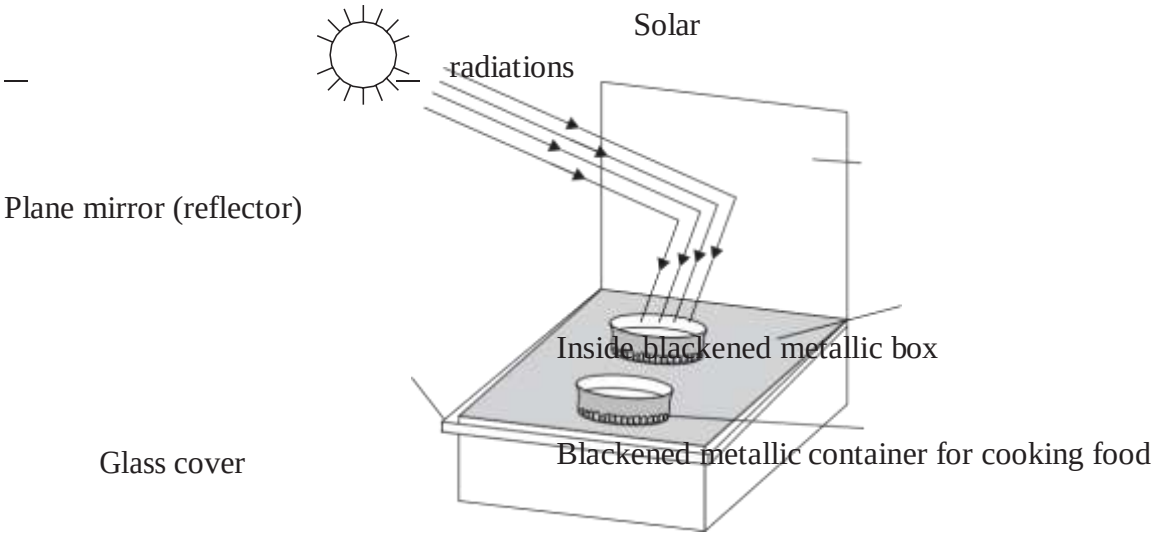


Fig. 2.5.3. Simple box-type solar cooker.

which covers the black insulated box within which the raw food is kept as shown in Fig. 2.7.3. A new design of solar cooker is now available which involves a spherical reflector (concave or parabolic reflector) instead of plane mirror that has more heating effect and hence greater efficiency.

The food cooked in solar cookers is more nutritious due to slow heating. However it has the limitation that it cannot be used at night or on cloudy days. Moreover, the direction of the cooker has to be adjusted according to the direction of the sun rays.

(¿v) So1ar water heater: Et consists of an insulated box painted black from inside and having a glass lid to receive and store solar heat. Enside the box it has black painted copper coil through which cold water is made to flow in, which gets heated and flows out into a storage tank. The hot water from the storage tank fitted on roof top is then supplied through pipes into buildings like hotels and hospitals.

(v) So1ar fnrnace: Here thousands of small plane mirrors are ar- ranged in concave reflectors, all of which collect the solar heat and produce as high a temperature as 3000°C.

(v¿) So1ar power p1ant: Solar energy is harnessed on a large scale by using concave reflectors which cause boiling of water to produce steam. The steam turbine drives a generator to produce electricity. A solar power plant (70 K Watt capacity) has been installed at Gurgaon, Haryana.

■ WIND ENERGY

The high speed winds have a lot of energy in them as kinetic energy due to their motion. The driving force of the winds is the sun. The wind energy is harnessed by making use of wind mills. The blades of the wind mill keep on rotating continuously due to the force of the striking wind. The rotational motion of the blades drives a number of machines like water pumps, flour mills and electric generators. A large number of wind mills are installed in clusters called wind farms, which feed power to the utility grid and produce a large amount of electricity. These farms are ideally located in coastal regions, open grasslands or hilly regions, particularly mountain passes and ridges where the winds are strong and steady. The minimum wind speed required for satisfactory working of a wind generator is 1S km/hr.

The wind power potentia1 of onr conntry is estimated to be abont 20,000 MN, whi1e at present we are generating abont 1020 MN. The largest wind farm of our country is near Kanyakumari in Tamil Nadu generating 380 MW electricity.

Wind energy is very useful as it does not cause any air pollution. After the initial installation cost, the wind energy is very cheap. Et is believed that by the middle of the century wind power would supply more than 10% of world³s electricity.

■ HYDROPOWER

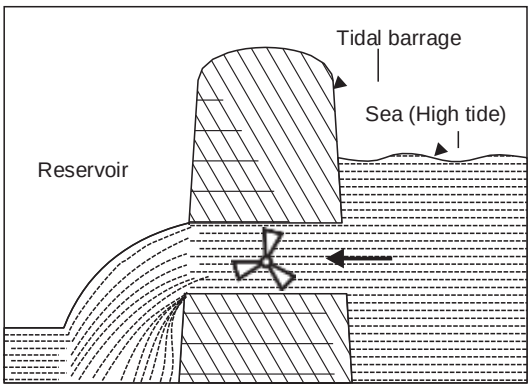
The water flowing in a river is collected by constructing a big dam where the water is stored and allowed to fall from a height. The blades of the turbine located at the bottom of the dam move with the fast moving water which in turn rotate the generator and produces electricity. We can also construct mini or micro hydel power plants on the rivers in hilly regions for harnessing the hydro energy on a small scale, but the minimum height of the water falls should be 10 metres. The hydropower potentia1 of rndia is estimated to be abont 4×10^{11} KN-honrs. Till now we have utilized only a little more than 11% of this potential.

Hydropower does not cause any pollution, it is renewable and normally the hydro power projects are multi-purpose projects helping in controlling floods, used for irrigation, navigation etc. However, big dams are often associated with a number of environmental impacts which have already been discussed in the previous section.

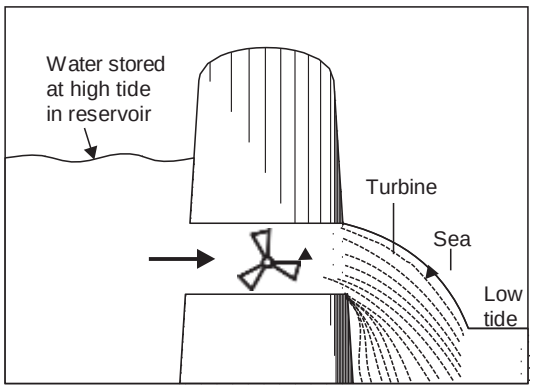
■ TIDAL ENERGY

Ocean tides produced by gravitational forces of sun and moon contain enormous amounts of energy. The ‘high tide’ and ‘1ow tide’ refer to the rise and fall of water in the oceans. A difference of several meters is required between the height of high and low tide to spin the turbines. The tidal energy can be harnessed by constructing a tidal barrage. During high tide, the sea-water flows into the reservoir of the barrage and turns the turbine, which in turn produces electricity by rotating the generators. During low tide, when the sea-level is low, the sea water stored in the barrage reservoir flows out into the sea and again turns the turbines. (Fig. 2.7.4)

There are only a few sites in the world where tidal energy can be suitably harnessed. The bay of Fundy Canada having 17-18 m high tides has a potential of 7,000 MW of power generation. The tidal mill at La Rance, France is one of the first modern tidal power mill. En Endia Gulf of Cambay, Gulf of Kutch and the Sunder bans deltas are the tidal power sites.



(a)



(b)

Fig. 2.5.4. Water flows into the reservoir to turn the turbine at high tide (*a*), and flows out from the reservoir to the sea, again turning the turbine at low tide (*b*).

■ OCEAN THERMAL ENERGY (OTE)

The energy available due to the difference in temperature of water at the surface of the tropical oceans and at deeper levels is called Ocean Thermal Energy. A difference of 20°C or more is required between surface water and deeper water of ocean for operating OTEC (Ocean Thermal Energy Conversion) power plants. The warm surface water of ocean is used to boil a liquid like ammonia. The high pressure vapours of the liquid formed by boiling are then used to turn the turbine of a generator and produce electricity. The colder water from the deeper oceans is pumped to cool and condense the vapours into liquid. Thus the process keeps on going continuously for 24 hours a day.

■ GEOTHERMAL ENERGY

The energy harnessed from the hot rocks present inside the earth is called geothermal energy. High temperature, high pressure steam fields exist below the earth³s surface in many places. This heat comes from the fission of radioactive material naturally present in the rocks. En some places, the steam or the hot water comes out of the ground naturally through cracks in the form of natnra1 geysers as in Manikaran, Kullu and Sohana, Haryana. Sometimes the steam or boiling water underneath the earth do not find any place to come out. We can artificially drill a hole up to the hot rocks and by putting a pipe in it makethe steam or hot water gush out through the pipe at high pressure which turns the turbine of a generator to produce electricty. En USA and New Zealand, there are several geothermal plants working successfully.

■ BIOMASS ENERGY

Biomass is the organic matter produced by the plants or animals which include wood, crop residues, cattle dung, manure, sewage, agricultural wastes etc. Biomass energy is of the following types :

(a) Energy P1antations: Solar energy is trapped by green plants through photosynthesis and converted into biomass energy. Fast grow- ing trees like cottonwood, poplar and Leucaena, non-woody herbaceous grasses, crop plants like sugarcane, sweet sorghum and sugar beet, aquatic weeds like water hyacinth and sea-weeds and carbohydrate rich potato, cereal etc. are some of the important energy plantations. They may produce energy either by burning directly or by getting converted into burnable gas or may be converted into fuels by fermentation.

(&) Petro-crops: Certain latex-containing plants like Zuphor&¿as and oil palms are rich in hydrocarbons and can yield an oil like sub- stance under high temperature and pressure. This oily material may be burned in diesel engines directly or may be refined to form gasoline. These plants are popularly known as petro-crops.

(c) Agricn1tnra1 and Urban Naste biomass: Crop residues, bagasse (sugarcane residues), coconut shells, peanut hulls, cotton stalks etc. are some of the common agricultural wastes which produce energy by burning. Animal dung, fishery and poultry waste and even human refuse are examples of biomass energy. En Brazil 30 % of electricity is obtained from burning bagasse. En rural Endia, animal dung cakes are burnt to produce heat. About 80 % of rural heat energy requirements are met by burning agricultural wastes, wood and animal dung cakes.

En rural areas these forms of waste biomass are burned in open furnaces called 'Chn1has³ which usually produce smoke and are not so efficient (efficiency is <8 %). Now improved Chulhas with tall chimney have been designed which have high efficiency and are smokeless.

The burning of plant residues or animal wastes cause air pollution and produce a lot of ash as waste residue. The burning of dung destroys essential nutrients like N and P. Et is therefore, more useful to convert the biomass into biogas or bio fuels.

■ BIOGAS

Biogas is a mixture of methane, carbon dioxide, hydrogen and hydrogen sulphide, the major constituent being methane. Biogas is produced by anaerobic degradation of animal wastes (sometimes plant wastes) in the presence of water. Anaerobic degradation means break down of organic matter by bacteria in the absence of oxygen.

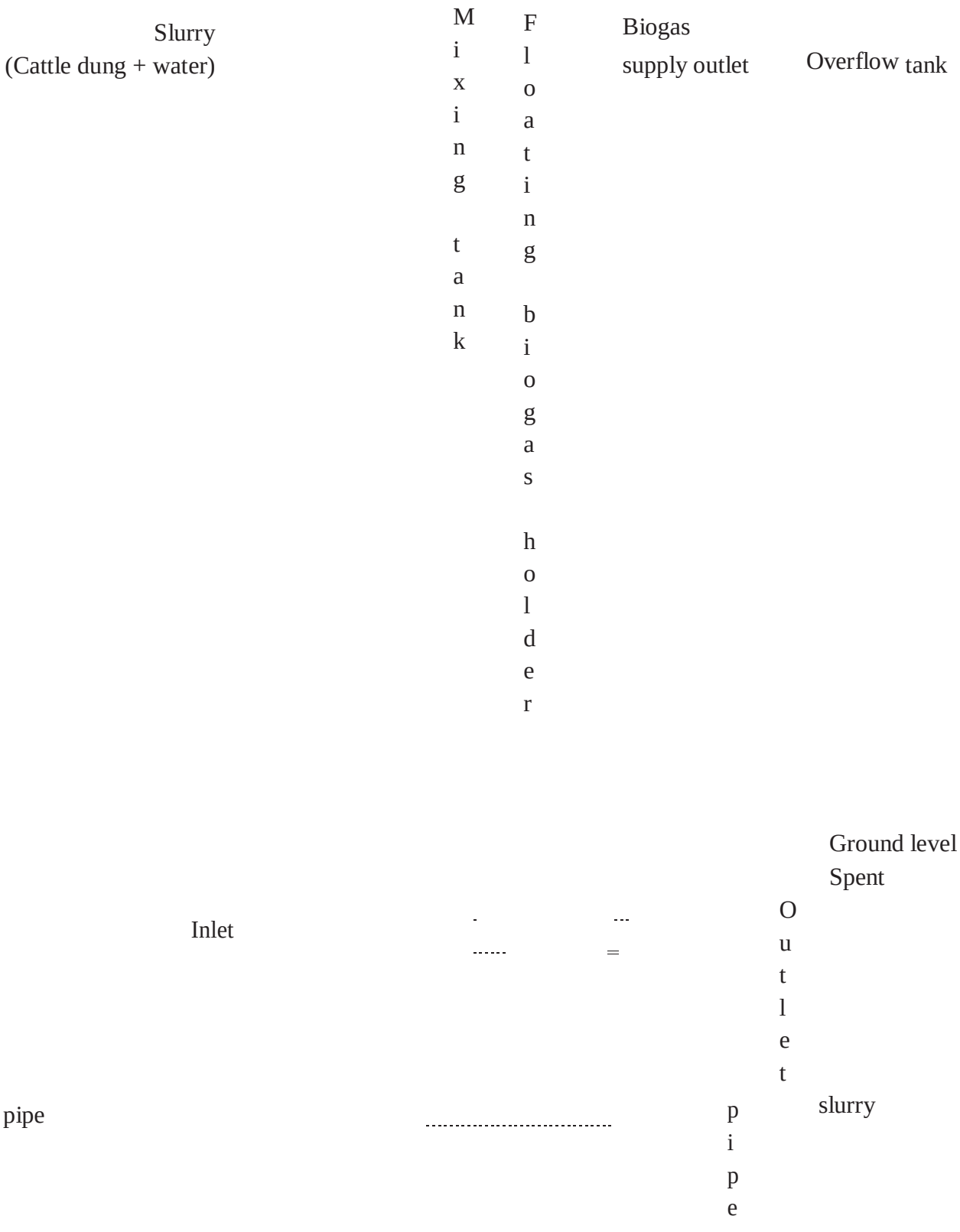
Biogas is a non-polluting, clean and low cost fuel which is very useful for rural areas where a lot of animal waste and agricultural waste are available. Endia has the largest cattle population in the world (240 million) and has tremendous potential for biogas production. From cattle dung alone, we can produce biogas of a magnitude of 22,700 Mm^3 annually. A sixty cubic feet gobar gas plant can serve the needs of one average family.

Biogas has the following main advantages : Et is clean, non- polluting and cheap. There is direct supply of gas from the plant and there is no storage problem. The sludge left over is a rich fertilizer containing bacterial biomass with most of the nutrients preserved as such. Air-tight digestion/degradation of the animal wastes is safe as it eliminates health hazards which normally occur in case of direct use of dung due to direct exposure to faecal pathogens and parasites.

Biogas plants used in our country are basically of two types:

1. Floating gas-holder type and 2. Fixed-dome type.

1. F1oating gas ho1der type biogas p1ant: This type has a well- shaped digester tank which is placed under the ground and made up of bricks. En the digester tank, over the dung slurry an inverted steel drum floats to hold the bio-gas produced. The gas holder can move which is controlled by a pipe and the gas outlet is regulated by a valve. The digester tank has a partition wall and one side of it receives the dung- water mixture through inlet pipe while the other side discharges the spent slurry through outlet pipe. (Fig 2.7.7)


Slurry
(Cattle dung + water)
Mixing tank
Floating biogas holder
Biogas supply outlet
Overflow tank
Ground level
Spent
Inlet
Outlet pipe
slurry
Underground

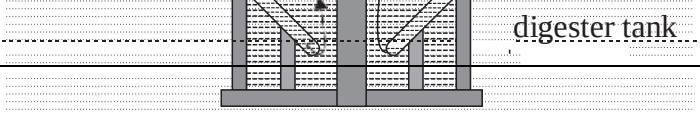


Fig. 2.5.5. Floating gas holder type biogas plant.

Sometimes corrosion of steel gas-holder leads to leakage of biogas. The tank has to be painted time and again for maintenance which increases the cost. Hence another type was designed as discussed below :

2. Fixed dome type biogas p1ant: The structure is almost similar to that of the previous type. However, instead of a steel gas-holder there is dome shaped roof made of cement and bricks. Enstead of partition- ing, here there is a single unit in the main digester but it has inlet and outlet chambers as shown in Fig 2.7.6.

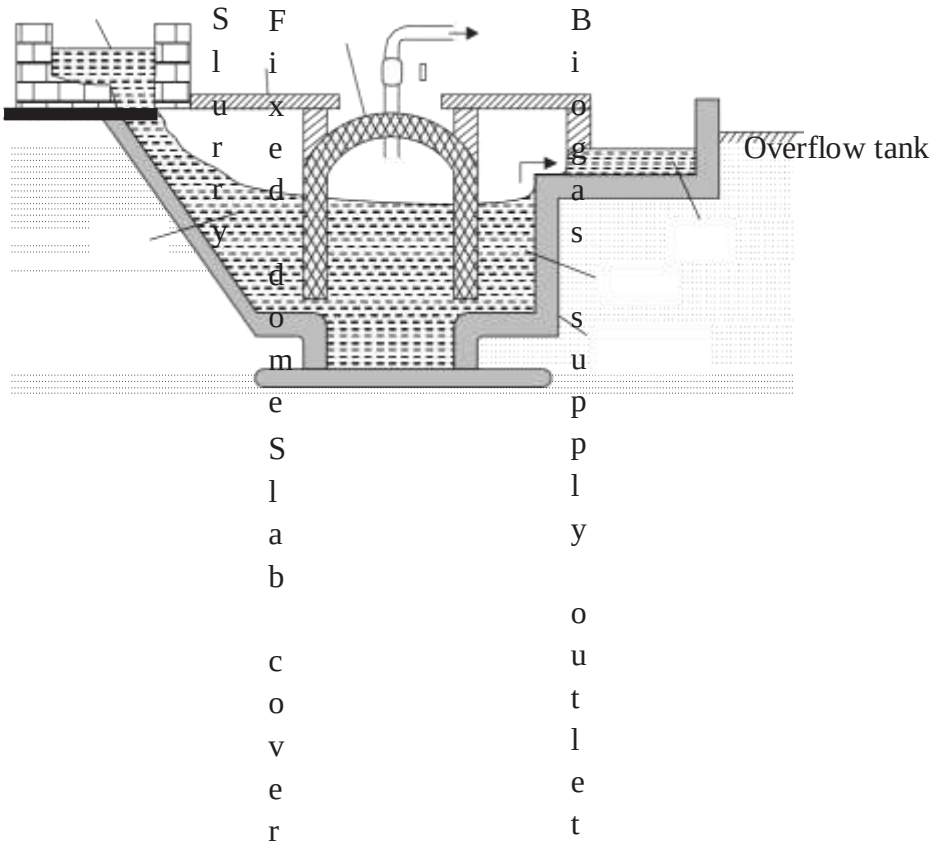


Fig. 2.5.6. Fixed dome type Biogas plant.

The Ministry of Non-Conventional Energy Sources (MNES) has been promoting the Biogas Programme

in Endia. Out of the various models, the important ones used in rural set-up are KVEC Model

(Floating drum type), Janta Model (Fixed dome type), Deenbandhu Model (Fixed dome type), Pragati Model (floating drum type), Ganesh Model (KVEC type but made of bamboo and polythene sheet) and Ferro-cement digester Model (KVEC type with ferro-cement digester).

■ BIOFUELS

Biomass can be fermented to alcohols like ethanol and methanol which can be used as fuels. Ethanol can be easily produced from carbohydrate rich substances like sugarcane. Et burns clean and is non-polluting. However, as compared to petrol its calorific value is less and therefore, produces much less heat than petrol.

Gasoho1 is a common fuel used in Brazil and Zimbabwe for running cars and buses. En Endia too gasohol is planned to be used on trial basis in some parts of the country, to start with in Kanpur. Gasohol is a mixture of ethanol and gasoline.

Methano1 is very useful since it burns at a lower temperature than gasoline or diesel. Thus the bulky radiator may be substituted by sleek designs in our cars. Methanol too is a clean, non-polluting fuel.

Methanol can be easily obtained from woody plants and ethanol from grain-based or sugar-containing plants.

■ HYDROGEN AS A FUEL

As hydrogen burns in air, it combines with oxygen to form water and a large amount of energy (170 kilojoules per gram) is released. Due to its high, rather the highest calorific value, hydrogen can serve as an excel- lent fuel. Moreover, it is non-polluting and can be easily produced. Production of Hydrogen is possible by thermal dissociation, photoly- sis or electrolysis of water:

(¿) By thermal dissociation of water (at 3000°K or above) hydrogen (H_2) is produced.

(¿¿) Thermochemically, hydrogen is produced by chemical reaction
of water with some other chemicals in 2-3 cycles so that we do not need the high temperatures as in direct thermal method and ultimately H_2 is produced.

(¿¿¿) Electrolytic method dissociates water into hydrogen (H_2) and oxygen by making a current flow through it.

(¿v) Photolysis of water involves breakdown of water in the presence of sun light to release hydrogen. Green plants also have photolysis of water during photosynthesis. Efforts are underway to trap hydrogen molecule which is produced during photosynthesis.

However, hydrogen is highly inflammable and explosive in nature. Hence, safe handling is required for using H_2 as a fuel. Also, it is difficult to store and transport. And, being very light, it would have to be stored in bulk.

Presently, H_2 is used in the form of liquid hydrogen as a fuel in spaceships.

(&) Non-Renewab1e Energy Sonrces

These are the fossil fuels like coal, petroleum, natural gas and nuclear fuels. These were formed by the decomposition of the remains of plants and animals buried under the earth millions of years ago. The fuels are very precious because they have taken such a long time to be formed and if we exhaust their reserves at such a fast rate as we have been doing, ever since we discovered them, then very soon we will lose these resources forever.

■ COAL

Coal was formed 277-370 million years ago in the hot, damp regions of the earth during the carboniferous age. The ancient plants along the banks of rivers and swamps were buried after death into the soil and due to the heat and pressure gradually got converted into peat and coal over millions of years of time. There are mainly three types of coal, namely ant2racite (hard coal), bituminous (Soft coal) and lignite (brown coal). Anthracite coal has maximum carbon (90%) and calorific value (8700 kcal/kg.) Bituminous, lignite and peat contain 80, 70 and 60% carbon, respectively. Coal is the most abundant fossil fuel in the world. At t2e ¢resent rate of usage, t2e coal reserves are li#ely to last for about 200 years and if its use increases by 2% ¢er year, t2en it will last for anot2er 6S years.

Endia has about 7% of world³s coal and Endian coal is not very good in terms of heat capacity. Major coal fields in Endia are Raniganj, Jharia, Bokaro, Singrauli, and Godavari valley. The coal states of Endia are Jharkhand, Orissa, West Bengal, Madhya Pradesh, Andhra Pradesh and Maharashtra. Anthracite coal occurs only in J & K.

When coal is burnt it produces carbon dioxide, which is a greenhouse gas responsible for causing enhanced global warming. Coal also contains impurities like sulphur and therefore as it burns the smoke contains toxic gases like oxides of sulphur and nitrogen.

■ PETROLEUM

Et is the lifeline of global economy. There are 13 countries in the world having 67% of the petroleum reserves which together form the

OPEC (Organization of Petroleum exporting countries). About 1/4th of the oil reserves are in Saudi Arabia.

At the present rate of usage, the world³s crude oil reserves are estimated to get exhausted in just 40 years. Some optimists, however, believe that there are some yet undiscovered reserves. Even then the crude oil reserves will last for another 40 years or so. Crude petroleum is a complex mixture of alkane hydrocarbons. Hence it has to be purified and refined by the process of /rac5¿onal d¿s5¿lla5¿on, during which process different constituents separate out at different temperatures. We get a large variety of products from this, namely, petroleum gas, kerosene, petrol, diesel, fuel oil, lubricating oil, paraffin wax, asphalt, plastic etc.

Petroleum is a cleaner fuel as compared to coal as it burns completely and leaves no residue. Et is also easier to transport and use. That is the reason why petroleum is preferred amongst all the fossil fuels.

Liqnefied petro1enm gas (LPG): The main component of petroleum is butane, the other being propane and ethane. The petroleum gas is easily converted to liquid form under pressure as LPG. Et is odourless, but the LPG in our domestic gas cylinders gives a foul smell. This is, in fact, due to ethyl mercaptan, a foul smelling gas, added to LPG so that any leakage of LPG from the cylinder can be detected instantaneously.

Oil fields in Endia are located at Digboi (Assam), Gujarat Plains and Bombay High, offshore areas in deltaic coasts of Gadavari, Krishna, Kaveri and Mahanadi.

■ NATURAL GAS

Et is mainly composed of methane (97%) with small amounts of propane and ethane. Et is a fossil fuel. Natural gas deposits mostly accompany oil deposits because it has been formed by decomposing remains of dead animals and plants buried under the earth. Natnra1 gas is the c1eanest fossi1 fne1. Et can be easily transported through pipelines. Et has a high calorific value of about 70KJ/G and burns without any smoke.

Currently, the amount of natural gas deposits in the world are of the order of 80, 470 g m^{-3}. Russia has maximum reserves (40%), followed by Eran (14%) and USA (7%). Natural gas reserves are found in association with all the oil fields in Endia. Some new gas fields have been found in Tripura, Jaisalmer, Off-shore area of Mumbai and the Krishna Godavari Delta.

Natural gas is used as a domestic and industrial fuel. Et is used as a fuel in thermal power plants for generating electricity. Et is used as a source of hydrogen gas in fertilizer industry and as a source of carbon in tyre industry.

Compressed natnra1 gas (CNG): Et is being used as an alternative to petrol and diesel for transport of vehicles. Delhi has totally switched over to CNG where buses and auto rickshaws run on this new fuel. CNG use has greatly reduced vehicular pollution in the city.

Synthetic natnra1 gas (SNG): Et is a mixture of carbon monoxide and hydrogen. Et is a connecting link between a fossil fuel and substituted natural gas. Low grade coal is initially transformed into synthetic gas by gasification followed by catalytic conversion to methane.

■ NUCLEAR ENERGY

Nuclear energy is known for its high destructive power as evidenced from nuclear weapons. The nuclear energy can also be harnessed for providing commercial energy. Nuclear energy can be generated by two types of reactions:

(¿) Nuclear K¿ss¿on: Et is the nuclear change in which nucleus of certain isotopes with large mass numbers are split into lighter nuclei on bombardment by neutrons and a large amount of energy is released through a chain reaction as shown in Fig. 2.7.7(a).

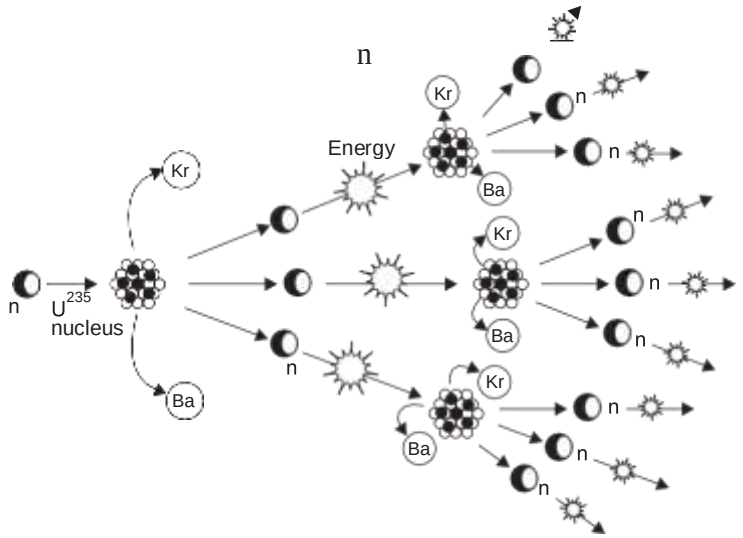


Fig. 2.5.7. (*a*) Nuclear fission—a chain reaction initiated by one neutron that bombards a Uranium (U^{235}) nucleus, releasing a huge quantity of energy, two smaller nuclei (Ba, Kr) and 3 neutrons.

$_{92}U^{237} + {}_{0}n^{1} \square\square\square {}_{36}Kr^{92} + {}_{76}Ba^{141} + 3\ {}_{0}n^{1}$ + Energy Nuclear Reactors make use of nuclear chain reaction. En order to
control the rate of fission, only 1 neutron released is allowed to strike for splitting another nucleus. Uranium-237 nuclei are most commonly used in nuclear reactors.

(¿¿) Nuclear /us¿on: Here two isotopes of a light element are forced together at extremely high temperatures (1 billion °C) until they fuse to form a heavier nucleus releasing enormous energy in the process. Et is difficult to initiate the process but it releases more energy than nuclear fission. (Fig. 2.7.7 (&))

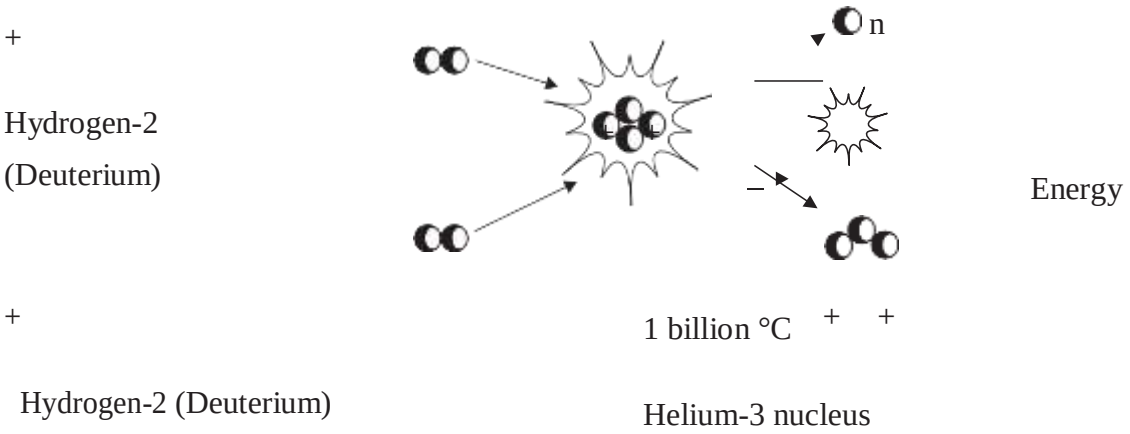


Fig. 2.5.7. (*b*) Nuclear fusion reaction between two hydrogen-2 nuclei, which take place at a very high temperature of 1 billion °C; one neutron and one fusion nucleus of helium-3 is formed along with a huge amount of energy.

$_{1}H^{2} + {}_{1}H^{2} \square\square\square {}_{3}He^{2} + {}_{0}n^{1}$ + Energy

Two hydrogen-2 (Deuterium) atoms may fuse to form the nu- cleus of Helium at 1 billion °C and release a huge amount of energy. Nuclear fusion reaction can also take place between one Hydrogen-2 (Deuterium) and one Hydrogen-3 (Tritium) nucleus at 100 million °C forming Helium-4 nucleus, one neutron and a huge amount of energy.

Nuclear energy has tremendous potential but any leakage from the reactor may cause devastating nuclear pollution. Disposal of the nuclear waste is also a big problem.

Nuclear power in Endia is still not very well developed. There are four nuclear power stations with an installed capacity of 2007 MW.

These are located at Tarapur (Maharashtra), Rana Pratap Sagar near Kota (Rajasthan), Kalpakkam (Tamil Nadu) and Narora (U.P.).

2.6. LAND RESOURCES

■ LAND AS A RESOURCE

Land is a finite and valuable resource upon which we depend for our food, fibre and fuel wood, the basic amenities of life. Soil, especially the top soil, is classified as a renewable resource because it is continuously regenerated by natural process though at a very slow rate. About 200-1000 years are needed for the formation of one inch or 2.7 cm soil, depending upon the climate and the soil type. But, when rate of erosion is faster than rate of renewal, then the soil becomes a non- renewable resource.

■ LAND DEGRADATION

With increasing population growth the demands for arable land for producing food, fibre and fuel wood is also increasing. Hence there is more and more pressure on the limited land resources which are getting degraded due to over-exploitation. Soil degradation is a real cause of alarm because soil formation is an extremely slow process as discussed above and the average annual erosion rate is 20-100 times more than the renewal rate.

Soil erosion, water-logging, salinization and contamination of the soil with industrial wastes like fly-ash, press-mud or heavy metals all cause degradation of land.

■ SOIL EROSION

The literal meaning of 'soil erosion³ is wearing away of soil. Soil ero- sion is defined as the movement of soil components, especially surface- litter and top soil from one place to another. Soil erosion results in the loss of fertility because it is the top soil layer which is fertile. Ef we look at the world situation, we find that one third of the world³s cropland is getting eroded. Two thirds of the seriously degraded lands lie in Asia and Africa.

Soil erosion is basically of two types based upon the cause of erosion:

(¿) Norma1 erosion or geo1ogic erosion: caused by the gradual removal of top soil by natural processes which bring an equilibrium between physical, biological and hydrological activities and maintain a natural balance between erosion and renewal.

(¿¿) Acce1erated erosion: This is mainly caused by anthropogenic (man-made) activities and the rate of erosion is much faster than the rate of formation of soil. Overgrazing, deforestation and mining are some important activities causing accelerated erosion.

There are two types of agents which cause soil erosion:

(¿) C1imatic agents: water and wind are the climatic agents of soil erosion. Water affects soil erosion in the form of torrential rains, rapid flow of water along slopes, run-off, wave action and melting and movement of snow.

Nater indnced soi1 erosion is of the following types:

- 32eet erosion: when there is uniform removal of a thin layer of soil from a large surface area, it is called sheet erosion. This is usually due to run-off water.
- Rill erosion: When there is rainfall and rapidly running water produces finger-shaped grooves or rills over the area, it is called rill erosion.
- Gully erosion: Et is a more prominent type of soil erosion. When the rainfall is very heavy, deeper cavities or gullies are formed, which may be U or V shaped.
- 3li¢ erosion: This occurs due to heavy rainfall on slopes of hills and mountains.
- 3tream ban# erosion: During the rainy season, when fast run- ning streams take a turn in some other direction, they cut the soil and make caves in the banks.

Nind erosion is responsible for the following three types of soil movements:

- 3altation: This occurs under the influence of direct pressure of stormy wind and the soil particles of 1-1.7 mm diameter move up in vertical direction.
- 3us¢ension: Here fine soil particles (less than 1 mm dia) which are suspended in the air are kicked up and taken away to distant places.
- 3urface cree¢: Here larger particles (7-10 mm diameter) creep over the soil surface along with wind.

(¿¿) Biotic agents: Excessive grazing, mining and deforestation are the major biotic agents responsible for soil erosion. Due to these processes the top soil is disturbed or rendered devoid of vegetation cover. So the land is directly exposed to the action of various physical forces facilitating erosion. Overgrazing accounts for 37% of the world³s soil

erosion while deforestation is responsible for 30% of the earth³s seriously eroded lands. Unsustainable methods of farming cause 28% of soil erosion.

Deforestation without reforestation, overgrazing by cattle, sur- face mining without land reclamation, irrigation techniques that lead to salt build-up, water-logged soil, farming on land with unsuitable terrain, soil compaction by agricultural machinery, action of cattle tram- pling etc make the top soil vulnerable to erosion.

Soi1 Conserration Practices

En order to prevent soil erosion and conserve the soil the following conservation practices are employed:

(¿) Conserrationa1 ti11 farming: En traditional method the land is ploughed and the soil is broken up and smoothed to make a planting surface. However, this disturbs the soil and makes it susceptible to ero- sion when fallow (i.e. without crop cover). Conservational till farm- ing, popularly known as no-ti11-farming causes minimum disturbance to the top soil. Here special tillers break up and loosen the subsurface soil without turning over the topsoil. The tilling machines make slits in the unploughed soil and inject seeds, fertilizers, herbicides and a little water in the slit, so that the seed germinates and the crop grows suc- cessfully without competition with weeds.

(¿¿) Contonr farming: On gentle slopes, crops are grown in rows across, rather than up and down, a practice known as contour farming. Each row planted horizontally along the slope of the land acts as a small dam to help hold soil and slow down loss of soil through run-off water.

(¿¿¿) Terracing: Et is used on still steeper slopes are converted into a series of broad terraces which run across the contour. Terracing retains water for crops at all levels and cuts down soil erosion by controlling run off. En high rainfall areas, ditches are also provided behind the terrace to permit adequate drainage (Plate E, a).

(¿v) Strip cropping: Here strips of crops are alternated with strips of soil saving covercrops like grasses or grass-legume mixture. Whatever run-off comes from the cropped soil is retained by the strip of cover- crop and this reduces soil erosion. Nitrogen fixing legumes also help in restoring soil fertility (Plate E, &).

Plate I(a) Terrace farming Plate I(b) Strip cropping

(v¿) A11ey cropping: Et is a form of inter-cropping in which crops are planted between rows of trees or shrubs. This is also called Agro forestry. Even when the crop is harvested, the soil is not fallow because trees and shrubs still remain on the soil holding the soil particles and prevent soil erosion (Plate E, c).

Nind breaks or she1terbe1ts: They help in reducing erosion caused by strong winds. The trees are planted in long rows along the cultivated land boundary so that wind is blocked. The wind speed is substantially reduced which helps in preventing wind erosion of soil (Plate E, d).

Thus, soil erosion is one of the world³s most critical problems and, if not slowed, will seriously reduce

Plate I(c) Alley cropping

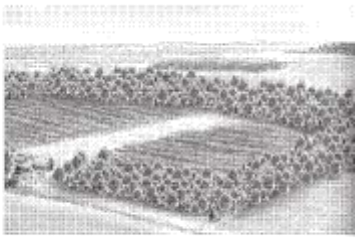


Plate I(d) Shelter belt

agricultural and forestry production, and degrade the quality of aquatic ecosystems as well due to increased siltation. Soil erosion, is in fact, a gradual process and very often the cumulative effects becomes visible only when the damage has already become irreversible. The best way to control soil erosion is to maintain adequate vegetational cover over the soil.

Water Logging

En order to provide congenial moisture to the growing crops, farmers usually apply heavy irrigation to their farmland. Also, in order to leach down the salts deeper into the soil, the farmer provides more irrigation

water. However, due to inadequate drainage and poor quality irrigation water there is accumulation of water underground and gradually it forms a continuous column with the water table. We call these soils as waterlogged soils which affect crop growth due to inhibition of exchange of gases. The pore-spaces between the soil particles get fully drenched with water through the roots.

Water logging is most often associated with salinity because the water used for irrigation contains salts and the soils get badly degraded due to erroneous irrigation practices. The damages caused by some major irrigation projects is shown is Table 2.6.1.

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Mining: Mining operations for extracting minerals and fossil fuels like coal often involves vast forest areas. Mining from shallow deposits is done by snrface mining while that from deep deposits is done by snb-snrface mining. More than 80,000 ha of land of the country is presently under the stress of mining activities. Mining and its associated activities require removal of vegetation along with underlying soil mantle and overlying rock masses. This results in defacing the topography and destruction of the landscape in the area.

Large scale deforestation has been reported in Mussorie and Dehradun valley due to indiscriminate mining of various minerals over a length of about 40 Km. The forested area has declined at an average rate of 33% and the increase in non-forest area due to mining activities has resulted in relatively unstable zones leading to landslides.

Endiscriminate mining in forests of Goa since 1961 has destroyed more than 70,000 ha of forest land. Coal mining in Jharia, Raniganj and Singrauli areas have caused extensive deforestation in Jharkhand. Mining of magnesite and soap- stones have destroyed 14 ha of forest in the hill slopes at Khirakot, Kosi valley, Almora. Mining of radioactive minerals in Kerala, Tamilnadu and Karnataka are posing similar threats of deforestation. The rich forests of Western Ghats are also facing the same threat due to mining projects for excavation of copper, chromite, bauxite and magnetite.

■ DAMS AND THEIR EFFECTS ON FORESTS AND PEOPLE

Big dams and river valley projects have multi-purpose uses and have been referred to as "Temples o/ modern Znd¿a". However, these dams are also responsible for the destruction of vast areas of forests. Endia has more than 1770 large dams, the maximum being in the state of Maharashtra (more then 600), followed by Gujarat (more then 270) and Madhya Pradesh (130). The highest one is Tehr¿ dam, on river Bhagirathi in Uttaranchal and the largest in terms of capacity is Bhakra dam on river Satluj in H.P. Big dams have been in sharp focus of various environmental groups all over the world which is mainly because of several ecological problems including deforestation and socio-economic problems related to tribal or native people associated with them. The

S¿len5 Valley hydroelectric project was one of the first such projects situated in the tropical rain forest area of Western Ghats which attracted much concern of the people. The crusade aga¿ns5 5he ecolog¿cal damage and de/ores5a5¿on caused due 5o Tehr¿ dam was led &y Sh. Sunder lal Bahuguna, 5he leader o/ ✓h¿p#o movemen5. The cause o/ Sardar Sarovar Dam rela5ed

¿ssues has &een 5a#en up &y 5he env¿ronmen5al ac5¿v¿s5s Xedha 9a5e#ar, jo¿ned &y Arundha5¿ Aay and Ba&a Am5e.

For building big dams, large scale devastation of forests takes place which breaks the natural ecological balance of the region. Floods, droughts and landslides become more prevalent in such areas. Forests are the repositories of invaluable gifts of nature in the form of biodiversity and by destroying them (particularly, the tropical rain for- ests) we are going to lose these species even before knowing them. These species could be having marvelous economic or medicinal value and deforestation results in loss of this storehouse of species which have evolved over millions of years in a single stroke.

Sardar Sarorar Dam (Uprooted Forests And Triba1s):
A case stndy

The dam is situated on river Narmada and is spread over three states of Gujarat, Maharashtra and Madhya Pradesh. Although the project is aimed at providing irrigation water, drinking water and electricity to the three states, the environmental impacts of the project have raised challenging questions.

A total of 1,44,731 ha of land will be submerged by the dam, out of which 76,747 ha is forest land. A total of 773 villages are to be submerged by the Narmada Dam.

Submergence of about 40,000 ha of forest under Narmada Sagar, 13,800 ha under Sardar Sarovar and 2,700 ha under Omkareshwar would further create pressure on remaining forest areas in adjoining areas. Submergence area is very rich in wildlife e.g. tigers, panthers, bears, wolves, pangolins, hyenas, jackals, flying squirrels, antelopes, black bucks, chinkara, marsh crocodiles, turtles etc. Many of these species are listed in schedule E & EE of Wildlife Protection Act, 1972. Thus massive loss of these wildlife species is apprehended due to the devastation of the forest under the project.

As per the estimates of the Enstitute of Urban Affairs, New Delhi, the Narmada valley project will lead to eventual displacement of more than one million people, which is probably the largest

rehabilitation issue ever encountered as per the World Bank. Uprooting of the tribals and their forced shifting in far-flung areas may not be easily adjusted to. Besides serious economic deprivation, the displacement will affect the tribal peoples[3] culture, their beliefs, myths and rituals, festivals, songs and dances, all closely associated with the hills, forest and streams. Most of these tribals belong to poor, unprivileged schedule castes and tribes who are being uprooted from a place where they have lived for generations. The displaced persons have to undergo hardship and distress for the sake of development and prosperity of a larger section of the society. Et is therefore the duty of the project proponents and government to pay maximum attention for proper rehabilitation of the displaced tribals.

2.3 WATER RESOURCES

Water is an indispensable natural resource on this earth on which all life depends. About 97% of the earth³s surface is covered by water and most of the animals and plants have 60-67% water in their body.

Water is characterized by certain unique features which make it a marvellous resource:

(¿) Et exists as a liquid over a wide range of temperature i.e. from 0° to100°C.

(¿¿) Et has the highest specific heat, due to which it warms up and cools down very slowly without causing shocks of tempera- ture jerks to the aquatic life.

(¿¿¿) Et has a high latent heat of vaporization Hence, it takes a huge amount of energy for getting vaporized. That³s why it produces a cooling effect as it evaporates.

(¿v) Et is an excellent solvent for several nutrients. Thus, it can serve as a very good carrier of nutrients, including oxygen, which are essential for life. But, it can also easily dissolve various pollutants and become a carrier of pathogenic microorganisms.

(v) Due to high surface tension and cohesion it can easily rise through great heights through the trunk even in the tallest of the trees like Seguo¿a.

(v¿) Et has an anamolous expansion behaviour i.e. as it freezes, it expands instead of contracting and thus becomes lighter. Et is because of this property that even in extreme cold, the lakes freeze only on the surface. Being lighter the ice keeps floating, whereas the bottom waters remain at a higher temperature and therefore, can sustain aquatic organisms even in extreme cold.

The water we use keeps on cycling endlessly through the environment, which we call as Hydro1ogica1 Cyc1e. We have enormous resources of water on the earth amounting to about 1404 million Km^3. The water from various moist surfaces evaporates and falls again on the earth in the form of rain or snow and passes through living organisms and ultimately returns to the oceans. Every year about 1.4 inch thick layer of water evaporates from the oceans, more than 90% of which returns to the oceans through the hydrological cycle. Solar energy drives the water cycle by evaporating it from various water bodies, which

subsequently return through rainfall or snow. Plants too play a very important role by absorbing the groundwater from the soil and releasing it into the atmosphere by the process of transpiration.

Global distribution of water resources is quite uneven depending upon several geographic factors. Tropical rain forest areas receive maximum rainfall while the major world deserts occur in zones of dry, descending air (20-40° N and S) and receive very little rainfall.

■ WATER USE AND OVER-EXPLOITATION

Due to its unique properties water is of multiple uses for all living organisms. Water is absolutely essential for life. Most of the life processes take place in water contained in the body. Uptake of nutrients, their distribution in the body, regulation of temperature, and removal of wastes are all mediated through water.

Human beings depend on water for almost every developmental activity. Water is used for drinking, irrigation, transportation, washing and waste disposal for industries and used as a coolant for thermal power plants. Water shapes the earth³s surface and regulates our climate.

Nater nse by humans is of two types: water withdrawal: taking water from groundwater or surface water resource and water consnmption: the water which is taken up but not returned for reuse. Globally, only about 60 percent of the water withdrawn is consumed due to loss through evaporation.

With increasing human population and rapid development, the world water withdrawal demands have increased many folds and a large proportion of the water withdrawn is polluted due to anthropogenic activities. On a global average 70 percent of the water withdrawn is used for agriculture. En Endia, we use 93% of water in agricultural sector while in a country like Kuwait, which is water-poor, only 4% is used for watering the crops. About 27% of water on global average is used in industry, which again varies from a high of 70% in European countries to as low as 7% in less developed countries. Per capita use of water shows wide variations. En USA, an average family of 4 consumes more than 1000 M^3 of water per year, which is many times more than that in most developing countries.

Water: A Precious Natural Resource

Although water is very abundant on this earth, yet it is very precious. Out of the total water reserves of the world, about 97% is salty water

(marine) and only 3% is fresh water. Even this small fraction of fresh water is not available to us as most of it is locked up in polar ice caps and just 0.003% is readily available to us in the form of groundwater and surface water.

Overuse of groundwater for drinking, irrigation and domestic pur- poses has resulted in rapid depletion of groundwater in various regions leading to lowering of water table and drying of wells. Pollution of many of the groundwater aquifers has made many of these wells unfit for consumption.

Rivers and streams have long been used for discharging the wastes. Most of the civilizations have grown and flourished on the banks of rivers, but unfortunately, growth in turn, has been responsible for pollution of the rivers.

As per the United Nations estimates (2002), at least 101 billion people do not even have access to safe drinking water and 2.4 billion do not have adequate sanitation facilities. Encreasing population and expanding development would further increase the demands for wastes. Et is estimated that by 2024, two-thirds of the world population would be suffering from acute water shortage.

Groundwater

About 9.86% of the total fresh water resources is in the form of groundwater and it is about 37-70 times that of surface water supplies. Till some time back groundwater was considered to be very pure. However, of late, even groundwater aquifers have been found to be contaminated by leachates from sanitary landfills etc.

A layer of sediment or rock that is highly permeable and contains water is called an aqnifer. Layers of sand and gravel are good aquifers while clay and crystalline rocks (like granite) are not since they have low permeability. Aquifers may be of two types:

Unconfined aqnifers which are overlaid by permeable earth materials and they are recharged by water seeping down from above in the form of rainfall and snow melt.

Confined aqnifers which are sandwitched between two impermeable layers of rock or sediments and are recharged only in those areas where the aquifer intersects the land surface. Sometimes the recharged area is hundreds of kilometers away from the location of the well. Fig 2.2.1 shows the groundwater system. Groundwater is not static, it moves, though at a very slow rate of about a meter or so in a year.

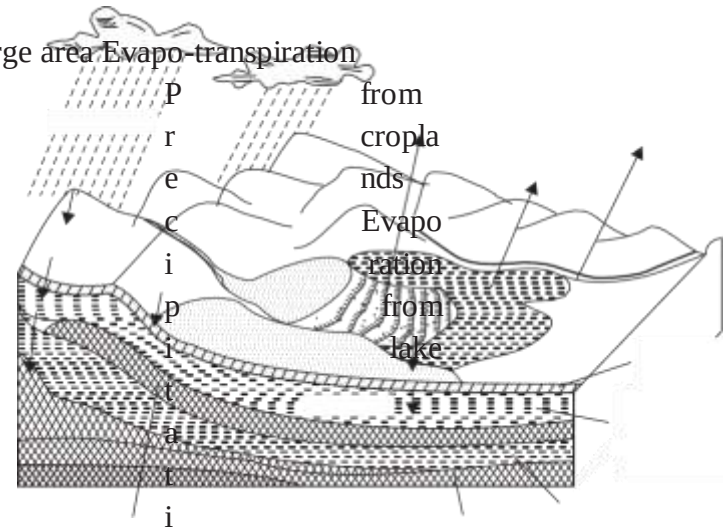

Unconfined aquifer recharge area
Evapo-transpiration from croplands
Evaporation from stream
Confined aquifer recharge area
Precipitation
Evaporation from lake
Infiltration
Infiltration
Less permeable material
Impermeable rock layer

Fig. 2.2.1. The groundwater system. An unconfined aquifer (water table) is formed when water collects over a rock or compact clay. A confined aquifer is formed sandwitched between two layers having very low permeability.

Effects of Groundwater Usage

(¿) Snbsidence: When groundwater withdrawal is more than its recharge rate, the sediments in the aquifer get compacted, a phenomenon known as ground su&s¿dence. Huge economic losses may occur due to this phenomenon because it results in the sinking of overlying land surface. The common problems associated with it include structural damage in buildings, fracture in pipes, reversing the flow of sewers and canals and tidal flooding.

(¿¿) Lowering of water tab1e: Mining of groundwater is done extensively in arid and semi-arid regions for irrigating crop fields. However, it is not advisable to do excessive mining as it would cause a sharp decline in future agricultural production, due to lowering of water table.

(¿¿¿) Nater 1ogging: When excessive irrigation is done with brackish water it raises the water table gradually leading to water-logging and salinity problems.

Surface Water

The water coming through precipitation (rainfall, snow) when does not percolate down into the ground or does not return to the atmos- phere as evaporation or transpiration loss, assumes the form of streams, lakes, ponds, wetlands or artificial reservoirs known as surface water. The surface water is largely used for irrigation, industrial use, public water supply, navigation etc. A country³s economy is largely depend- ent upon its rivers.

Nater rich rs. Nater poor conntries

The top ten water rich countries are Eceland, Surinam, Guyana, Papua New Guinea, Gabon, Solomon Eslands, Canada, Norway, Panama, and Brazil lying in the far north and have low evaporation losses.

The water poor countries include Kuwait, Egypt, United Arab Emirates, Malta, Jordon, Saudi Arabia, Singapore, Maldovia, Esrael and Oman, lying in the desert belt at about 17° to 27° Latitude and some of them like Malta and Singapore are densely populated areas resulting in low per capita water.

■ FLOODS

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

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

Floods have been regular features of some parts of Endia and Bangladesh causing huge economic loss as well as loss of life. People of Bangladesh are accustomed to moderate flooding during monsoon and they utilize the flood water for raising paddy. But, severe floods like that in 1970, 1988 and 1991 resulting from excessive Himalayan runoff and storms, had very disastrous consequences causing massive deaths and damages. En 1970, about one million people were drowned while 1,40,000 people died in 1991. Networking of rivers is being proposed at national level to deal with the problems of floods.

■ DROUGHTS

There are about 80 countries in the world, lying in the arid and semi- arid regions that experience frequent spells of droughts, very often extending up to year long duration. Nhen annna1 rainfa11 is be1ow norma1 and 1ess than eraporation, dronght conditions are created. Eronically, these drought- hit areas are often having a high population growth which leads to poor land use and makes the situation worse.

Anthropogenic canses: Drought is a meteorological phenomenon, but due to several anthropogenic causes like over grazing, deforestation, mining etc. there is spreading of the deserts tending to convert more areas to drought affected areas. En the last twenty years, Endia has experienced more and more desertification, thereby increasing the vulnerability of larger parts of the country to droughts.

Erroneous and intensive cropping pattern and increased exploitation of scarce water resources through well or canal irrigation to get high productivity has converted drought - prone areas into desertified ones. En Maharashtra there has been no recovery from drought for the last 30 years due to over-exploitation of water by sugarcane crop which has high water demands.

Remedia1 measnres: Endigenous knowledge in control of drought and desertification can be very useful for dealing with the problem. Carefully selected mixed cropping help optimize production and minimize the risks of crop failures. Social Forestry and Wasteland development can prove quite effective to fight the problem, but it should be based on proper understanding of ecological requirements and natural process, otherwise it may even boomrang. The Kolar district of Karnataka is one of the leaders in Social Forestry with World Bank Aid, but all its 11 talukas suffer from drought. Et is because the tree used for plantation here was Zucalyp5us which is now known to lower the water table because of its very high transpiration rate.

■ CONFLICTS OVER WATER

Endispensability of water and its unequal distribution has often led to inter-state or international disputes. Essues related to sharing of river water have been largely affecting our farmers and also shaking our governments. Some major water conflicts are discussed here.

- Nater conf1ict in the Midd1e East: Three river basins, namely the Jordan, the Tigris-Euphrates and the Nile are the shared water resources for Middle East countries. Ethiopia controls the head waters of 80% of Nile³s flow and plans to increase it.

Sudan too is trying to divert more water. This would badly affect Egypt, which is a desert, except for a thin strip of irrigated cropland along the river Nile and its delta.

The population of Egypt is likely to double in the next 20 years, thereby increasing its water crisis. Likewise there is a fierce battle for water among Jordan, Syria and Esrael for the Jordan River water share.

Turkey has abundant water and plans to build 22 dams on Tigris-Euphrates for Hydroelectric power generation. But, it would drastically reduce the flow of water to Syria and Eraq, lying downstream. Turkey dreams to become the region³s water Super power. Et plans to transport and sell water to starved Saudi Arabia, Kuwait, Syria, Esrael and Jordan. Probably, the next war in the Middle East would be fought over water and not oil.

- The rndns Nater Treaty: The Endus, one of the mightiest rivers is dying a slow death due to dams and barrages that have been built higher up on the river. The Sukkur barrage (1932), Ghulam Mohamad Barrage at Kotri (1978) and Tarbela and Chasma Dams on Jhelum, a tributary of Endus have resulted in severe shrinking of the Endus delta. En 1960, the Endus water treaty was established vide which Endus, the Jhelum and the Chenab were allocated to Pakistan and the Satluj, the Ravi and the Beas were allocated to Endia. Being the riparian state, Endia has pre-emptive right to construct barrages across all these rivers in Endian territory. However, the treaty requires that the three rivers allocated to Pakistan may be used for non~consump5¿ve purposes by Endia i.e. without changing its flow and quality. With improving political relations between the two countries it is desirable to work out techno-economic details and go for an integrated development of the river basin in a sustainable manner.
- The Canrery water dispnte: Out of Endia³s 18 major rivers, 17 are shared between different states. En all these cases, there are intense conflicts over these resources which hardly seem to resolve. The Cauvery river water is a bone of contention between Tamilnadu and Karnataka and the fighting is almost hundred years old. Tamilnadu, occupying the downstream region of the river wants water-use regulated in the upstream. Whereas, the upstream state Karnataka refuses to do so and claims its primacy over the river as upstream user. The river

water is almost fully utilized and both the states have increasing demands for agriculture and industry. The consumption is more in Tamilnadu than Karnataka where the catchment area is more rocky. On June 2,1990, the Cauvery Water Dispute Tribunal was set up which through an interim award directed Karnataka to ensure that 207 TMCF of water was made available in Tamil Nadu³s Mettur dam every year, till a settlement was reached. En 1991-92 due to good monsoon, there was no dispute due to good stock of water in Mettur, but in 1997, the situation turned into a crisis due to delayed rains and an expert Committee was set up to look into the matter which found that there was a complex cropping pattern in Cauvery basin. Sam&ra paddy in winter, Xurva¿ paddy in summer and some cash crops demanded intensive water, thus aggravating the water crisis. Proper selection of crop varieties, optimum use of water, better rationing, rational sharing patterns, and pricing of water are suggested as some measures to solve the problem.

- The Sat1nj-Yamnna 1ink (SYL) cana1 dispnte: The issue of sharing the Ravi-Beas waters and SYL issue between Punjab and Haryana is being discussed time and again and the case is in the Supreme Court. The Eradi Tribunal (1987) based the allocation of water on the basis of the time-inflow data of 20 years (1960-80), according to which 17.17 MAF (million acre feet) water was available. However, now it is argued by Punjab that in the last 17 years there has been consistent decline reducing the quantity to 14.34 MAF. The Supreme Court on January 17, 2002 directed Punjab to complete and commission the SYL within a year, failing which the Center was told to complete it. However, two years have passed, but neither the SYL has been completed nor the conflict over sharing of Ravi- Beas water is resolved.

The conflict is that Punjab being the riparian state for Beas, Ravi and Satluj stakes its claim, Haryana has faced acute shortage of water after it became a state in 1966 and has been trying to help it out by signing an MOU (Memorandum of understanding) with UP, Rajasthan and Delhi for allocation of Yamuna waters. The Yamuna basin covers the state of Haryana while the Endus basin covers Punjab.

The conflict revolving around sharing of river water needs to be tackled with greater understanding and objectivity.

Traditional Water Management System

En Endia, even today, there are several villages where water management is done not by the Errigation Department, but by local managers. En south Endia, a neer#atti manages the traditional tanks very efficiently based on his/her knowledge of the terrain, drainage and irrigation needs. They usually give preference to the tail end fields and decide per capita allocation of water based on the stock of available water in the tank and crop needs. En Maharashtra, the water mangers are called 2avaldars or jag2yas who manage and resolve conflicts by overseeing the water channels from main canal to the distributory canals. En Ladakh, the water manager is known as c2ur¢un who has got complete charge with full powers over allocation of available water. The major source of water is melt water from glaciers and snow supplementary by water from springs and marshes. The water is distributed to different fields through an intricate network of earthen channels.

En traditional water management, innovative arrangements ensure equitable distribution of water, which are democratically implemented. The 'gram-sabhas³ approve these plans publicly. While water disputes between states and nations often assume battle like situations, our traditional water managers in villages prove to be quite effective.

■ **BIG DAMS- BENEFITS AND PROBLEMS Benefits**

River valley projects with big dams have usually been considered to

play a key role in the development process due to their multiple uses. Endia has the distinction of having the largest number of river-valley projects. These dams are often regarded as a symbol of national development. The tribals living in the area pin big hopes on these projects as they aim at providing employment and raising the standard and quality of life. The dams have tremendous potential for economic upliftment and growth. They can help in checking floods and famines, generate electricity and reduce water and power shortage, provide irrigation water to lower areas, provide drinking water in remote areas and promote navigation, fishery etc.

Environmental Problems

The environmental impacts of big-dams are also too many due to which very often the big dams become a subject of controversy. The impacts can be at the upstream as well as downstream levels.

(C) The upstream problems include the following: (¿) Displacement of tribal people
(¿¿) Loss of forests, flora and fauna
(¿¿¿) Changes in fisheries and the spawning grounds (¿v) Siltation and sedimentation of reservoirs
(v) Loss of non-forest land
(v¿) Stagnation and waterlogging near reservoir
(v¿¿) Breeding of vectors and spread of vector-borne diseases (v¿¿¿) Reservoir induced seismicity (RES) causing earthquakes (¿x) Growth of aquatic weeds.
(x) Microclimatic changes.

(D) The downstream impacts include the following:
(¿) Water logging and salinity due to over irrigation (¿¿) Micro-climatic changes
(¿¿¿) Reduced water flow and silt deposition in river (¿v) Flash floods
(v) Salt water intrusion at river mouth
(v¿) Loss of land fertility along the river since the sediments carry- ing nutrients get deposited in the reservoir
(v¿¿) Outbreak of vector-borne diseases like malaria

Thus, although dams are built to serve the society with multiple uses, but it has several serious side-effects. That is why now there is a shift towards construction of small dams or mini-hydel projects.

2.4 MINERAL RESOURCES

Minerals are naturally occurring, inorganic, crystalline solids having a definite chemical composition and characteristic physical properties. There are thousands of minerals occurring in different parts of the world. However, most of the rocks, we see everyday are just composed of a few common minerals like quartz, feldspar, biotite, dolomite, calcite, laterite etc. These minerals, in turn, are composed of some elements like silicon, oxygen, iron, magnesium, calcium, aluminium etc.

■ USES AND EXPLOITATION

Minerals find use in a large number of ways in everyday use in domestic, agricultural, industrial and commercial sectors and thus form a very important part of any nation³s economy. The main uses of minerals are as follows:

(¿) Development of industrial plants and machinery. (¿¿) Generation of energy e.g. coal, lignite, uranium.
(¿¿¿) Construction, housing, settlements.
(¿v) Defence equipments-weapons, armaments.
(v) Transportation means.
(v¿) Communication- telephone wires, cables, electronic devices. (v¿¿) Medicinal system- particularly in Ayurvedic System.
(v¿¿¿) Formation of alloys for various purposes (e.g. phosphorite). (¿x) Agriculture–as fertilizers, seed dressings and fungicides (e.g.
zineb containing zinc, Maneb-containing manganese etc.).
(x) Jewellery–e.g. Gold, silver, platinum, diamond.

Based on their properties, minerals are basically of two types:

(¿) Non metallic minerals e.g. graphite, diamond, quartz, feldspar. (¿¿) Metallic minerals e.g. Bauxite, laterite, haematite etc.

Use of metals by human beings has been so extensive since the very beginning of human civilization that two of the major epochs of human history are named after them as Bronze Age and Eron Age. The reserves of metals and the technical know-how to extract them have been the key elements in determining the economy and political power of nations. Out of the various metals, the one used in maximum quantity is Eron and steel (740 million metric tons annually) followed by manganese, copper, chromium, aluminium and Nickel.

Distribution and uses of some of the major metallic and non- metallic minerals are given in Tables 2.3.1 and 2.3.2.

Tab1e 2.3.1. Major reserres and important nses of some of the major meta1s

Meta1	Major World Reserres	Major Uses
Aluminium	Australia, Guinea	Packaging food items, transpor-tation, utensils, electronics

	, Jamaica	
Chromium	CES, South Africa	For making high strength steel alloys, En textile/tanning industries
Copper	U.S.A., Canada, CES	Electric and electronic goods, building, construction, vessels

	, Chile, Zambia	
Eron	CES, South America, Canada, U.S	Heavy machinery, steel produc-tion transportation means

	. A .	
Lead	North America, U.S.A., CES	Leaded gasoline, Car batteries, paints, ammunition
Manganese	South Afric	For making high strength, heat-resistant steel alloys
Plat	Sout	Use in automobi

inum group	h Africa, CES	les, catalytic converters, electronics, medical uses.
Gold	South Afric	Ornaments, medical use, elec-tronic use, use in aerospace
Silver	Canada, South Afric	Photography, electronics jewellery

	a , M e x i c o	
N i c k e l	C E S , C a n a d a , N e w C a l e d o n i a	Che mical indus try, steel alloy s

Tab1e 2.3.2. Major nses of some non-meta11ic minera1s

N o n - m e t	Major Uses

a 1 M i n e r a 1	
S i l i c a t e m i n e r a l s	Sand and gravel for construction, bricks, paving etc.
L i m e s t o n e	Used for concrete, building stone, used in agriculture for neutralizing acid soils, used in cement industry
G y p s u m	Used in plaster wall-board, in agriculture
P o t	Used as fertilizers

ash, phosphorite	
Sulphur pyrites	Used in medicine, car battery, industry.

Et is evident from the Tables that the CES countries (The Com- monwealth of Endependent States ¿.e. 12 repubics of former USSR), the United States of America, Canada, South Africa and Australia are having the major world reserves of most of the metallic minerals. Due to huge mineral and energy resources, the USA became the richest and the most powerful nation in the world in even less than 200 years. Ja- pan too needs a mention here, as there are virtually no metal reserves, coal, oil and timber resources in Japan and it is totally dependent on other countries for its resources. But, it has developed energy efficient technologies to upgrade these resources to high quality finished prod- ucts to sustain its economy.

Minerals are sometimes classified as Critica1 and Strategic. Critica1 minera1s are essential for the economy of a nation e.g.
iron, aluminium, copper, gold etc.

Strategic minera1s are those required for the defence of a country
e.h. Manganese, cobalt, platinum, chromium etc.

Some Major Minerals of India

(a) Energy generating minera1s

Coal and lignite: West Bengal, Jharkhand, Orissa, M.P., A.P. Uranium (Pitchblende or Uranite ore): Jharkhand, Andhra Pradesh(Nellore, Nalgonda), Meghalaya, Rajasthan (Ajmer).

(&) Other commercia11y nsed minera1s

Aluminium (Baux¿5e ore): Jharkhand, West Bengal, Maharashtra, M.P., Tamilnadu.

Sron (haema5¿5e and magne5¿5e ore): Jharkhand, Orissa, M.P., A.P., Tamilnadu, Karnataka, Maharashtra and Goa.

Co¢¢er (✓opper 9yr¿5es): Rajasthan (Khetri), Bihar, Jharkhand, Karnataka, M.P., West Bengal, Andhra Pradesh and Uttaranchal.

■ ENVIRONMENTAL IMPACTS OF MINERAL EXTRACTION AND USE

The issue related to the limits of the mineral resources in our earth³s crust or in the ocean is not so significant. More important environ- mental concern arises from the impacts of extraction and processing of these minerals during mining, smelting etc.

rndian Scenario: Endia is the producer of 84 minerals the annual value of which is about Rs. 70,000 crore. At least six major mines need a mention here which are known for causing severe problems:

(¿) Jadngnda Uraninm Mine, Jharkhand—exposing local people to radioactive hazards.

(¿¿) Jharia coa1 mines, Jharkhand—underground fire leading to land subsidence and forced displacement of people.

(¿¿¿) Snkinda chromite mines, Orissa—seeping of hexavalent chromium into river posing serious health hazard, Cr^{6+} being highly toxic and carcinogenic.

(¿v) Kndremnkh iron ore mine, Karnataka—causing river pollution and threat to biodiversity.

(v) East coast Banxite mine, Orissa—Land encroachment and issue of rehabilitation unsettled.

(v¿) North-Eastern Coa1 Fie1ds, Assam—Very high sulphur contamination of groundwater.

rmpacts of mining: Mining is done to extract minerals (or fossil fuels) from deep deposits in soil by using snb-snrface mining or from shallow deposits by snrface mining. The former method is more destructive, dangerous and expensive including risks of occupational hazards and accidents.

Surface mining can make use of any of the following three types:

(a) Open~p¿5 m¿n¿ng in which machines dig holes and remove the ores (e.g. copper, iron, gravel, limestone, sandstone, marble, granite).

(&) Dredg¿ng in which chained buckets and draglines are used which scrap up the minerals from under-water mineral deposits.

(c) S5r¿p m¿n¿ng in which the ore is stripped off by using bulldozers, power shovels and stripping wheels (e.g. phosphate rocks).

The environmental damage caused by mining activities are as follows:

(¿) Deregetation and defacing of 1andscape: The topsoil as well as the vegetation are removed from the mining area to get access to the deposit. While large scale deforestation or devegetation leads to several ecological losses as already discussed in the previous section, the landscape also gets badly affected. The huge quantities of debris and tailings alongwith big scars and disruptions spoil the aesthetic value of the region and make it prone to soil erosion.

(¿¿) Snbsidence of 1and: This is mainly associated with underground mining. Subsidence of mining areas often results in tilting of buildings, cracks in houses, buckling of roads,

bending of rail tracks and leaking of gas from cracked pipe- lines leading to serious disasters.

(¿¿¿) Gronndwater contamination: Mining disturbs the natural hydrological processes and also pollutes the groundwater. Sulphur, usually present as an impurity in many ores is known to get converted into sulphuric acid through microbial action, thereby making the water acidic. Some heavy metals also get leached into the groundwater and contaminate it posing health hazards.

(¿v) Snrface water po11ntion: The acid mine drainage often con- taminates the nearby streams and lakes. The acidic water is detrimental to many forms of aquatic life. Sometimes radio- active substances like uranium also contaminate the water bodies through mine wastes and kill aquatic animals. Heavy metal pollution of water bodies near the mining areas is a common feature creating health hazards.

(v) Air po11ntion: En order to separate and purify the metal from other impurities in the ore, smelting is done which emits enormous quantities of air pollutants damaging the vegetation nearby and has serious environmental health impacts. The suspended particulate matter (SPM), SOx, soot, arsenic particles, cadmium, lead etc. shoot up in the atmosphere near the smelters and the public suffers from several health problems.

(v¿) Occnpationa1 Hea1th Hazards: Most of the miners suffer from various respiratory and skin diseases due to constant exposure to the suspended particulate matter and toxic substances. Miners working in different types of mines suffer from asbestosis, silicosis, black lung disease etc.

Remedia1 measnres: Safety of mine workers is usually not a priority subject of industry. Statistical data show that, on an average, there are 30 non-fatal but disabling accidents per ton of mineral produced and one death per 2.7 tons of mineral produced.

En order to minimize the adverse impacts of mining it is desirable to adopt eco-friendly mining technology. The low-grade ores can be better utilized by using microbia1-1eaching techniqne. The bacterium Th¿o&ac¿llus /errox¿dans has been successfully and economically used for extracting gold embedded in iron sulphide ore. The ores are inoculated with the desired strains of bacteria, which remove the impurities (like sulphur) and leave the pure mineral. This biological method is helpful from economic as well as environmental point of view.

Restoration of mined areas by re-vegetating them with appropri- ate plant species, stabilization of the mined lands, gradual restoration of flora, prevention of toxic drainage discharge and conforming to the standards of air emissions are essential for minimizing environmental impacts of mining.

CASE STUDrES

- Mining and qnarrying in Udaipnr

About 200 open cast mining and quarrying centers in Udaipur, about half of which are illegal are involved in stone mining including soapstone, building stone, rock phosphate and dolomite. The mines spread over 17,000 hectares in Udaipur have caused many adverse impacts on environment. About 170 tonnes of explosives are used per month in blasting. The overburden, washoff, discharge of mine water etc. pollute the water. The Maton mines have badly polluted the Ahar river. The hills around the mines are devoid of any vegetation except a few scattered patches and the hills are suffering from acute soil erosion. The waste water flows towards a big tank of "Bag Dara". Due to scarcity of water people are compelled to use this effluent for irrigation purpose.

The blasting activity has adversely affected the fauna and the animals like tiger, lion, deer and even hare, fox, wild cats and birds have disappeared from the mining area.

- Mining in Sariska Tiger Reserre in Arara11is

The Aravalli range is spread over about 692 km in the North-west Endia covering Gujarat, Rajasthan, Haryana and Delhi. The hill region is very rich in biodiversity as well as mineral resources. The Sariska tiger reserve has gentle slopy hills, vertical rocky valleys, flat plains as well as deep gorges. The reserve is very rich in wild life and has enormous mineral reserves like quartzite, Schists, marble and granite in abundance.

Mining operations within and around the Sariska Tiger reserve has left many areas permanently infertile and barren. The precious wild life is under serious threat. We must preserve the Aravalli series as a National Heritage and the Supreme Court on December 31st, 1991 has given a judgement in response to a Public Enterest Litigation of Tarun Bharat Sangh, an NGO wherein both Centre and State Government of Rajasthan have been directed to ensure that all mining activity within the park be stopped. More than 400 mines were shut immediately. But, still some illegal mining is in progress.

• Uraninm Mining in Na1gonda, A.P.—The pnb1ic hearing

The present reserves of Uranium in Jaduguda mines, Jharkhand can supply the yellow cake only till 2004. There is a pressing need for mining more uranium to meet the demands of Endia³s nuclear programme. The Uranium Corporation of Endia (UCEL) proposes to mine uranium from the deposits in Lambapur and Peddagattu villages of Nalgonda district in Andhra Pradesh and a processing unit at about 18 kms at Mallapur. The plan is to extract the ore of 11.02 million tons in 20 years. The EUCL is trying its best to allure the villagers through employment opportunities. But, experts charge the company for keeping silence on the possible contamination of water bodies in the area. The proposed mines are just 1 km from human habitation and hardly 10 km from Nagarjun Sagar Dam and barely 4 km from the Akkampalli reservoir which is Hyderabad³s new source of drinking water.

Et is estimated that 20 years of mining would generate about 7.7 million metric tones of radioactive waste of which 99.9% will be left behind. The villagers are very likely to be affected by the radioactive wastes. Though EUCL claims that there won³t be any such accidents, but no one can deny that it is a highly hazardous industry and safety measures cannot be overlooked. The pathetic condition of Jaduguda Uranium mines in Jharkhand where there is a black history of massive deaths and devastation have outraged the public, who don³t want it to be repeated for Nalgonda.

The proposed mines would cover about 447 ha of Yellapurum Reserve Forest and the Rajiv Gandhi Tiger Sanctuary. The public hearing held just recently in February, 2004 witnessed strong protests from NGOs and many villagers. The fate of the proposed mining is yet to be decided.

2.5 FOOD RESOURCES

We have thousands of edible plants and animals over the world out of which only about three dozen types constitute the major food of hu- mans. The main food resources include wheat, rice, maize, potato, barley, oats, cassava, sweet potato, sugarcane, pulses, sorghum, millet, about twenty or so common fruits and vegetables, milk, meat, fish and seafood. Amongst these rice, wheat and maize are the major grains, about 1700 million metric tons of which are grown each year, which is about half of all the agricultural crops. About 4 billion people in the developing countries have wheat and rice as their staple food.

Meat and milk are mainly consumed by more developed nations of North America, Europe and Japan who consume about 80% of the total. Fish and sea-food contribute about 70 million metric tons of high quality protein to the world³s diet. But there are indications that we have already surpassed sustainable harvests of fish from most of the world³s oceans.

The Food and Agriculture Organization (FAO) of United Na- tions estimated that on an average the minimum caloric intake on a global scale is 2,700 calories/day. People receiving less than 90% of these minimum dietary calories are called nndernonrished and if it is less than 80% they are said to be serions1y nndernonrished. Besides the minimum caloric intake we also need proteins, minerals etc. Defi- ciency or lack of nutrition often leads to ma1nntrition resulting in sev- eral diseases as shown in Table 2.4.1.

Tab1e 2.4.1. rmpacts of ma1nntrition

Deficiency	Hea1th Effect	No. of Cases	Deaths per year (in m

			i 1 1 i o n s)
P r o t e i n s a n d C a l o r i e s	S t u n t e d g r o w t h , K w a s h i o r k o r , M a r a s m u s	7 7 0 1 m i l l i o n	1 7 - 2 0

Eron	Anemia	370 million	0.77-1
Eodine	Goitre, Cretinism	170 million, 6 million	
Vitamin A	Blindness	6 million	

■ WORLD FOOD PROBLEMS

During the last 70 years world grain production has increased almost three times, thereby increasing per capita production by about 70%. But, at the same time population growth increased at such a rate in LDCs (Less developed countries) that it outstripped food production. Every year 40 million people (fifty percent of which are young children between 1 to 7 years) die of undernourishment and malnutrition. This means that every year our food ¢roblem is #illing as many ¢eo¢le as were #illed by t2e atomic bomb dro¢¢ed on Kiros2ima during World War SS. These startling statistical figures more than emphasize the need to increase our food production, equitably distribute it and also to control population growth.

rndian Scenario: Although Endia is the third largest producer of staple crops, an estimated 300 million Endians are still undernourished. Endia has only half as much 1and as USA, but it has nearly three times population to feed. Our food problems are directly related to popula- tion.

The Nor1d Food Snmmit, 1996 has set the target to reduce the number of undernourished to just half by 2017, which still means 410 million undernourished people on the earth.

■ IMPACTS OF OVERGRAZING AND AGRICULTURE

(C) Orergrazing

Livestock wealth plays a crucial role in the rural life of our country. Endia leads in live stock population in the world. The huge population of livestock needs to be fed and the grazing lands or pasture areas are not adequate. Very often we find that the live stock grazing on a particular piece of grassland or pasture surpass the carrying capacity. Carrying capacity of any system is the maximum population that can be supported by it on a sustainable basis. However, most often, the grazing pressure is so high that its carrying capacity is crossed and the sustainability of the grazing lands fails. Let us see what are the impacts of overgrazing.

rmpact of Orergrazing

(¿) Land Degradation: Overgrazing removes the vegetal cover over the soil and the exposed soil gets compacted due to which the operative soil depth declines. So the roots cannot go much deep into the soil and adequate soil moisture is not available. Organic recycling also declines in the ecosystem because not enough detritus or litter

remains on the soil to be decomposed. The humus content of the soil decreases and overgrazing leads to organically poor, dry, compacted soil. Due to trampling by cattle the soil loses infiltration capacity, which reduces percolation of water into the soil and as a result of this more water gets lost from the ecosystem along with surface run off. Thus over grazing leads to multiple actions resulting in loss of soil structure, hydraulic conductivity and soil fertility.

(¿¿) Soi1 Erosion: Due to overgrazing by cattle, the cover of veg- etation almost gets removed from the land. The soil becomes exposed and gets eroded by the action of strong wind, rainfall etc. The grass roots are very good binders of soil. When the grasses are removed, the soil becomes loose and susceptible to the action of wind and water.

(¿¿¿) Loss of nsefn1 species: Overgrazing adversely affects the composition of plant population and their regeneration capacity. The original grassland consists of good quality grasses and forbs with high nutritive value. When the livestock graze upon them heavily, even the root stocks which carry the reserve food for regeneration get destroyed. Now some other species appear in their place. These secondary species are hardier and are less nutritive in nature. Some livestock keep on overgrazing on these species also. Ultimately the nutritious, juicy fodder giving species like ✓enchrus, D¿chan5h¿um, 9an¿cum and He5eropogon etc. are replaced by unpalatable and sometimes thorny plants like 9ar5hen¿um, Lan5ana, Xan5h¿um etc. These species do not have a good capacity of binding the soil particles and, therefore, the soil becomes more prone to soil erosion.

As a result of overgrazing vast areas in Arunachal Pradesh and Meghalaya are getting invaded by thorny bushes, weeds etc. of low fodder value. Thus overgrazing makes the grazing land lose its regenerating capacity and once good quality pasture land gets converted into an ecosystem with poor quality thorny vegetation.

(D) Agricn1tnre

En the early years of human existence on this earth, man was just a hunter gatherer and was quite like other animal species. Some 10,000 to 12,000 years ago he took to agriculture by cultivating plants of his own choice. He used the practice of S1ash and bnrn cn1tiration or shifting cn1tiration, which is still prevalent in many tribal areas, as in the North East Hills of Endia. The type of agriculture practiced these days is very different from the traditional ones and their outputs in terms of yield as well as their impacts on the environment show lots of differences.

1. Traditiona1 agricn1tnre and its impacts: Et usually involves a small plot, simple tools, naturally available water, organic fertilizer and a mix of crops. Et is more near to natural conditions and usually it results in low production. Et is still practiced by about half the global population.

The main impacts of this type of agriculture are as follows:

(¿) Deforestation: The slash and burn of trees in forests to clear the land for cultivation and frequent shifting result in loss of forest cover.

(¿¿) Soi1 erosion: Clearing of forest cover exposes the soil to wind, rain and storms, thereby resulting in loss of top fertile layer of soil.

(¿¿¿) Dep1etion of nntrients: During slash and burn the organic matter in the soil gets destroyed and most of the nutrients are taken up by the crops within a short period, thus making the soil nutrient poor which makes the cultivators shift to another area.

2. Modern Agricn1tnre and its impacts: Et makes use of hybrid seeds of selected and single crop variety, high-tech equipments and lots of energy subsidies in the form of fertilizers, pesticides and irrigation water. The food production has increased tremendously, evidenced by "green revolution". However, it also gave rise to several problematic off-shoots as discussed below:

(¿) rmpacts re1ated to high yie1ding rarieties (HYV): The uses of HYVs encourage monoculture i.e. the same genotype is grown over vast areas. En case of an attack by some pathogen, there is total devas- tation of the crop by the disease due to exactly uniform conditions, which help in rapid spread of the disease.

(¿¿) Ferti1izer re1ated prob1ems:

(a) Micronntrient imba1ance: Most of the chemical fertilizers used in modern agriculture have nitrogen, phosphorus and potassium (N, P, K) which are essential macronutrients. Farm- ers usually use these fertilizers indiscriminately to boost up crop growth. Excessive use of fertilizers cause m¿cronu5r¿en5 ¿m&alance. For example, excessive fertilizer use in Punjab and Haryana has caused deficiency of the micronutrient zinc in the soils, which is affecting productivity of the soil.

(&) Nitrate Po11ntion: Nitrogenous fertilizers applied in the fields often leach deep into the soil and ultimately contaminate the ground water. The nitrates get concentrated in the water and when their concentration exceeds 27 mg/L, they become the cause of a serious health hazard called "B1ne Baby Syndrome" or methaemoglobinemia. This disease affects the

infants to the maximum extent causing even death. En Denmark, England, France, Germany and Netherlands this problem is quite prevalent. En Endia also, problem of nitrate pollution exists in many areas.

(c) Entrophication: Excessive use of N and P fertilizers in the agricultural fields leads to another problem, which is not related to the soil, but relates to water bodies like lakes. A large proportion of nitrogen and phosphorus used in crop fields is washed off and along with runoff water reach the water bodies causing over nourishment of the lakes, a process known as Entrophication (eu=more, trophic=nutrition). Due to eutrophication the lakes get invaded by algal blooms. These algal species grow very fast by rapidly using up the nutrients. They are often toxic and badly affect the food chain. The algal species quickly complete their life cycle and die thereby adding a lot of dead organic matter. The fishes are also killed and there is a lot of dead matter that starts getting decomposed. Oxygen is consumed in the process of decomposition and very soon the water gets depleted of dissolved oxygen. This further affects aquatic fauna and ultimately anaerobic conditions are created where only pathogenic anaerobic bacteria can survive. Thus, due to excessive use of fertilizers in the agricultural fields the lake ecosystem gets degraded. This shows how an unmindful action can have far reaching impacts.

(¿¿¿) Pesticide related prob1ems: Thousands of types of pesticides are used in agriculture. The first generation pesticides include chemicals like sulphur, arsenic, lead or mercury to kill the pests. DDT (Dichlorodiphenyl trichloroethane) whose insecticidal properties were discovered by Paul Mueller in 1939 belongs to the second generation pesticides. After 1940, a large number of synthetic pesticides came into use. Although these pesticides have gone a long way in protecting our crops from huge losses occurring due to pests, yet they have a number of side-effects, as discussed below:

(a) Creating resistance in pests and prodncing new pests: Some individuals of the pest species usually survive even after pesticide spray. The survivors give rise to highly resistant generations. About 20 species of pests are now known which have become immune to all types of pesticides and are known as "Snper pests".

(&) Death of non-target organisms: Many insecticides are broad spectrum poisons which not only kill the target species but also several non-target species that are useful to us.

(c) Bio1ogica1 magnification: Many of the pesticides are non- biodegradable and keep on accumulating in the food chain, a process called biological magnification. Since human beings occupy a high trophic level in the food chain, hence they get the pesticides in a bio-magnified form which is very harmful.

(¿v) Nater Logging: Over irrigation of croplands by farmers for good growth of their crop usually leads to waterlogging. Enadequate drainage causes excess water to accumulate underground and gradually forms a continuous column with the water table. Under water-logged conditions, pore-spaces in the soil get fully drenched with water and the soil-air gets depleted. The water table rises while the roots of plants do not get adequate air for respiration. Mechanical strength of the soil declines, the crop plants get lodged and crop yield falls.

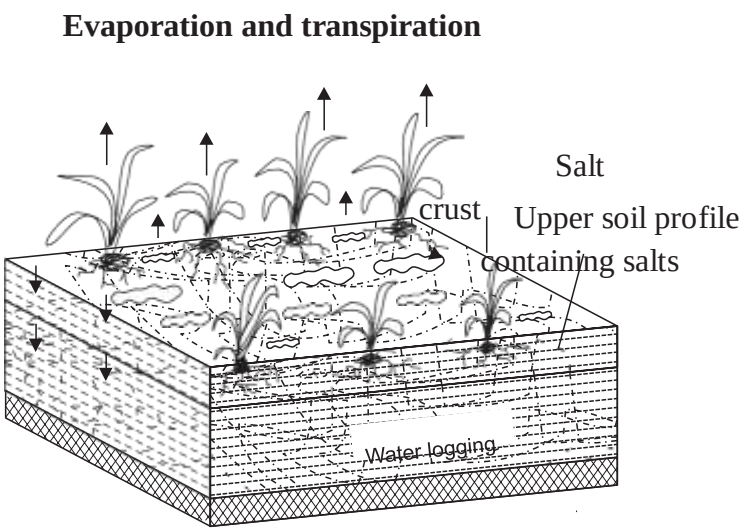
En Punjab and Haryana, extensive areas have become water-logged where adequate canal water supply or tube-well water encouraged the farmers to use it over-enthusiastically leading to water-logging problem.

Preventing excessive irrigation, sub-surface drainage technology and bio-drainage with trees like Eucalyptus are some of the remedial measures to prevent water-logging.

(v) Sa1inity prob1em: At present one third of the total cultivable land area of the world is affected by salts. En Endia about seven million hectares of land are estimated to be salt—affected which may be saline or sodic. Saline soils are characterized by the accumulation of soluble salts like sodium chloride, sodium sulphate, calcium chloride, magnesium chloride etc. in the soil profile. Their electrical conductivity is more than 4 dS/m. Sodic soils have carbonates and bicarbonates of sodium, the pH usually exceeds 8.0 and the exchangeable sodium percentage (ESP) is more than 17%.

Canses: A Major cause of salinization of soil is excessive irrigation. About 20% of the world³s croplands receive irrigation with canal water or ground water which unlike rainwater often contains dissolved salts. Under dry climates, the water evaporates leaving behind salts in the upper soil profile (Fig. 2.4.1)

Thousands of hectares of land area in Haryana and Punjab are affected by soil salinity and alkalinity. Salinity causes stunted plant growth and lowers crop yield. Most of the crops cannot tolerate high salinity.



Salinization

- Addition of salts with saline irrigation water
- Evapo-transpiration leaves behind salts
- Salt-build up occurs in upper soil profile

Waterlogging

- Rain water and irrigation water percolate down
- Water table rises

Fig. 2.4.1. Salinization and water logging.

Remedy: The most common method for getting rid of salts is to flush them out by applying more good quality water to such soils. Another method is laying underground network of perforated drainage pipes for flushing out the salts slowly. This sub-surface drainage system has been tried in the experimental station of CSSRE at Sampla, Haryana. The Central Soil Salinity Research Enstitute (CSSRE) located in Karnal, Haryana has to its achievement the success story of conver ting Xar¿/a V¿ran village to Xar¿/a A&ad i.e. '/rom 5he &arren land 5o produc5¿ve land³ through its research applications.

CASE STUDrES

Sa1inity and water 1ogging in Pnnjab, Haryana and Rajasthan : The first alarming report of salt-affected wasteland formation in connection with irrigation practices came from Haryana (then Punjab) in 1878. Et was reported that several villages in Panipat, Rohtak and Delhi lying in command area of Western Yamuna Canal were suffering from destructive saline efflorescence. The "Reh Committee" in 1886 drew the attention of the government on some vital points showing a close relationship between irrigation, drainage and spread of "reh" and "usar" soils.

The floods of 1947, 1970, 1972, 1974-76 in Punjab resulted in aggravated water logging with serious drainage problems. Entroduction of canal irrigation in 1.2 m ha in Haryana resulted in rise in water-table followed by water-logging and salinity in many irrigated areas causing huge economic losses as a result of fall in crop productivity. Rajasthan too has suffered badly in this regard following the biggest irrigation project “Endira Gandhi Canal Project” and the sufferings of a big area in Western Rajasthan have changed from a condition of “water-starved wasteland” to that of a “water soaked wasteland”.

2.7. ENERGY RESOURCES

Energy consumption of a nation is usually considered as an index of its development. This is because almost all the developmental activities are directly or indirectly dependent upon energy. We find wide disparities in per capita energy use between the developed and the developing nations.

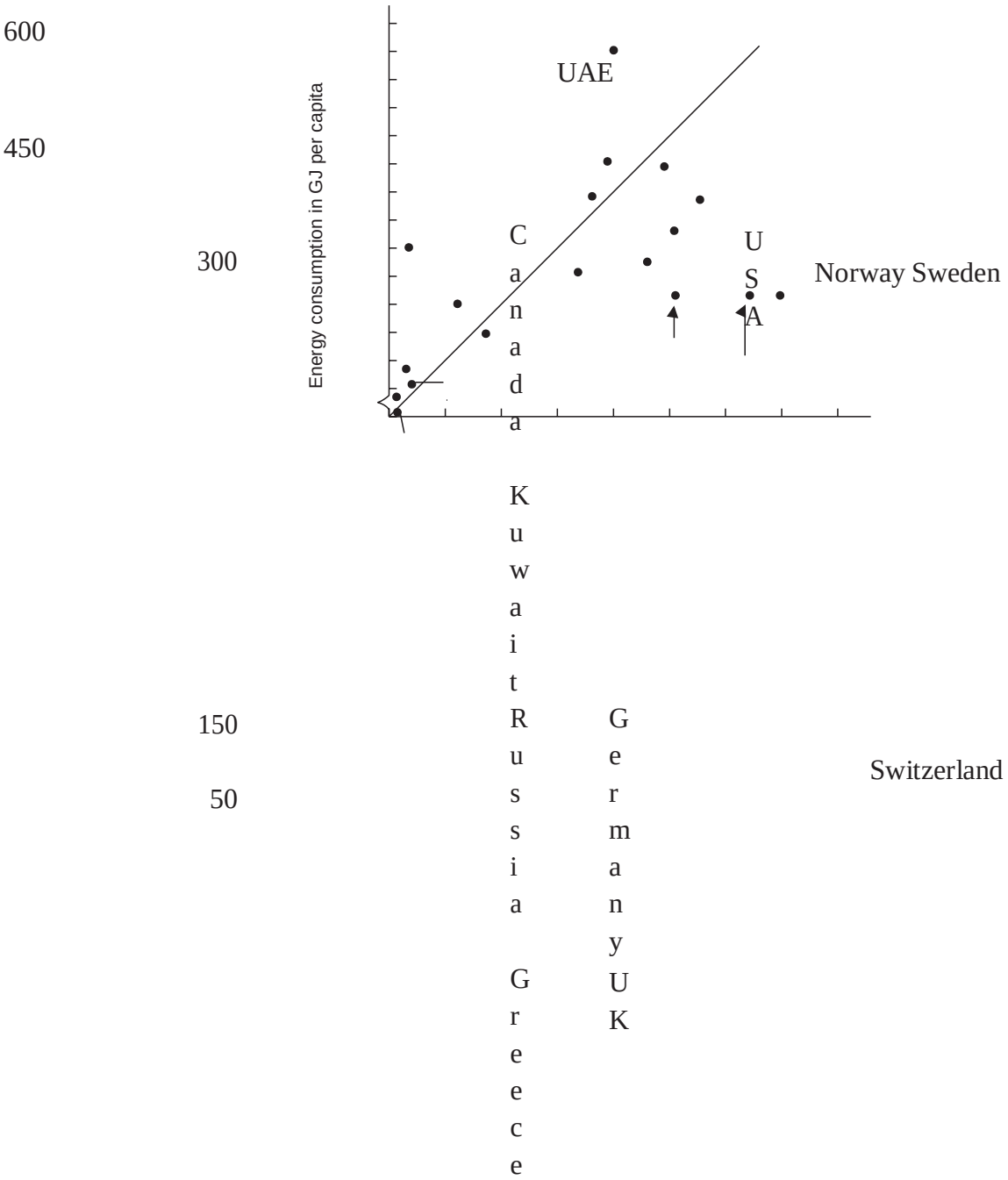
The first form of energy technology probably was the fire, which produced heat and the early man used it for cooking and heating purposes. Wind and hydropower have also been in use for the last 10,000 years. The invention of steam engines replaced the burning of wood by coal and coal was later replaced to a great extent by oil. En 1970³s due to Eranian revolution and Arab oil embargo the prices of oil shooted up. This ultimately led to exploration and use of several alternate sources of energy.

■ GROWING ENERGY NEEDS

Development in different sectors relies largely upon energy. Agriculture, industry, mining, transportation, lighting, cooling and heating in buildings all need energy. With the demands of growing population the world is facing further energy deficit. The fossil fuels like coal, oil and natural gas which at present are supplying 97% of the commercial energy of the world resources and are not going to last for many more years. Our life style is changing very fast and from a simple way of life we are shifting to a luxurious life style. Ef you just look at the number of electric gadgets in your homes and the number of private cars and scooters in your locality you will realize that in the last few years they have multiplied many folds and all of them consume energy.

Developed countries like U.S.A. and Canada constitute about 7% of the world³s population but consume one fourth of global energy resources. An average person there consumes 300 GJ (Giga Joules, equal to 60 barrels of oils) per year. By contrast, an average man in a poor country like Bhutan, Nepal or Ethiopia consumes less than 1 GJ in a year. So a person in a rich country consumes almost as much energy in a single day as one person does in a whole year in a poor country. This clearly shows that our life-style and standard of living are closely related to energy needs. Fig. 2.7.1 shows the strong correlation between per capita energy use and GNP (Gross National product). U.S.A., Norway, Switzerland etc. with high GNP show high energy use while Endia, China etc have low GNP and low energy use. Bahrain and Quatar

are oil rich states (UAE) and hence their energy consumption and GNP are more, although their development is not that high.



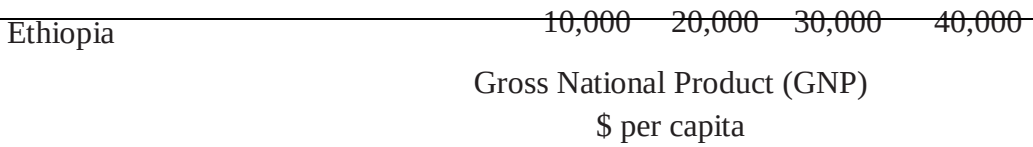


Fig. 2.5.1. Per capita energy use and GNP (Data from World Resources Institute, 1997)

■ RENEWABLE AND NON-RENEWABLE ENERGY SOURCES

A source of energy is one that can provide adequate amount of energy in a usable form over a long period of time. These sources can be of two types:

(3) Renewab1e Resonrces which can be generated continnons1y in natnre and are inexhanstib1e e.g. wood, solar energy, wind energy, tidal energy, hydropower, biomass energy, bio-fuels, geo-thermal energy and hydrogen. They are also known as non-conventional sources of energy and they can be used again and again in an endless manner.

(4) Non-renewab1e Resonrces which hare accnmn1ated in natnre orer a 1ong span of time and cannot be qnick1y rep1enished when exhansted e.g. coal, petroleum, natural gas and nuclear fuels like uranium and thorium.

Wood is a renewable resource as we can get new wood by growing a sapling into a tree within 17-20 years but it has taken millions of years for the formation of coal from trees and cannot be regenerated in our life time, hence coal is not renewable. We will now discuss various forms of renewable and non-renewable energy resource.

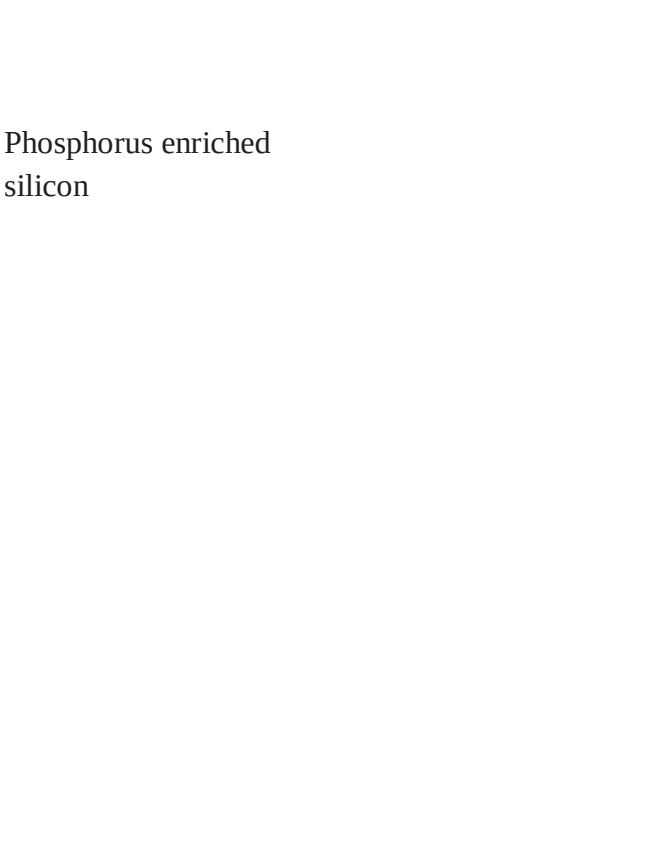
(c) Renewab1e Energy Resonrces

So1ar energy: Sun is the ultimate source of energy, directly or indirectly for all other forms of energy. The nuclear fusion reactions occurring inside the sun release enormous quantities of energy in the form of heat and light. The solar energy received by the near earth space is approximately 1.4 kilojoules/second/m^2 known as solar con- stant.

Traditionally, we have been using solar energy for drying clothes and food-grains, preservation of eatables and for obtaining salt from sea-water. Now we have several techniques for harnessing solar en- ergy. Some important solar energy harvesting devices are discussed here.

(¿) So1ar heat co11ectors: These can be passive or active in nature. Passive solar heat collectors are natural materials like stones, bricks etc. or material like glass which absorb heat during the day time and release it slowly at night. Active solar collectors pump a heat absorbing medium (air or water) through a small collector which is normally placed on the top of the building.

(¿¿) So1ar ce11s: They are also known as photovoltaic cells or PV cells. Solar cells are made of thin wafers of semi conductor materials like silicon and gallium. When solar radiations fall on them, a potential difference is produced which causes flow of electrons and produces electricity. Silicon can be obtained from silica or sand, which is abundantly available and inexpensive. By using gallium arsenide, cadmium sulphide or boron, efficiency of the PV cells can be improved. The potential difference produced by a single PV cell of 4 cm^2 size is about 0.4-0.7 volts and produces a current of 60 milli amperes. Fig. 2.7.2 (a) shows the structure of a solar cell.



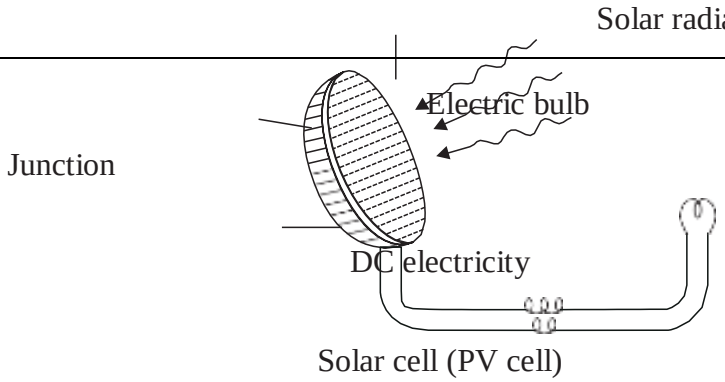


Fig. 2.5.2. (*a*) Solar cell.

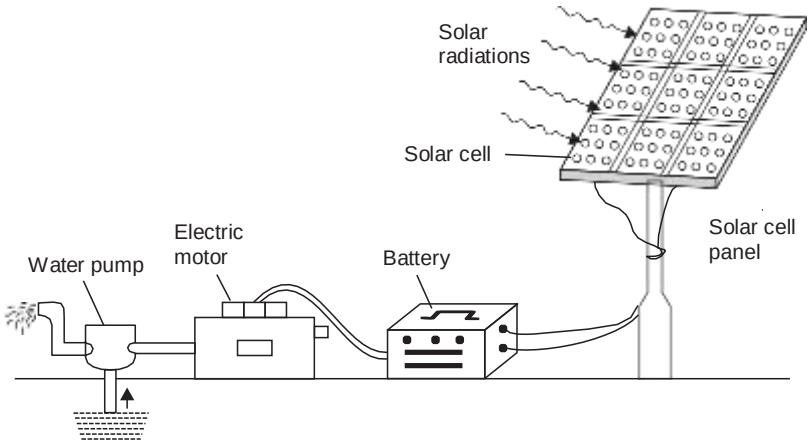


Fig. 2.5.2. (*b*) A solar pump run by electricity produced by solar cells.

A group of solar cells joined together in a definite pattern form a solar panel which can harness a large amount of solar energy and can produce electricity enough to run street-light, irrigation water pump etc. (Fig. 2.7.2).

Solar cells are widely used in calculators, electronic watches, street lighting, traffic signals, water pumps etc. They are also used in artifi- cial satellites for electricity generation. Solar cells are used for running radio and television also. They are more in use in remote areas where conventional electricity supply is a problem.

(¿¿¿) So1ar cooker: Solar cookers make use of solar heat by reflecting the solar radiations using a mirror directly on to a glass sheet

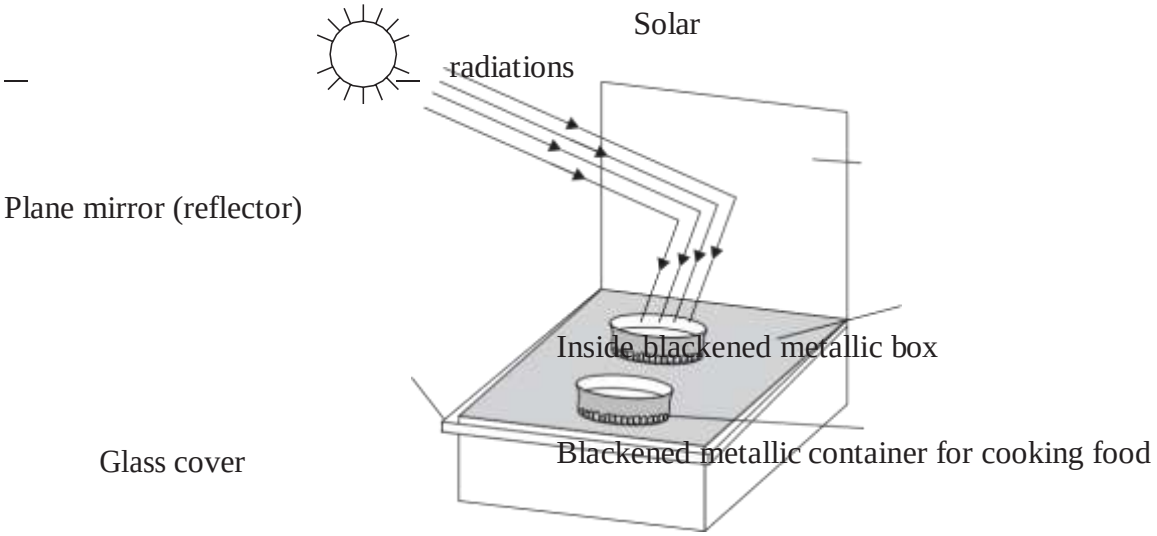


Fig. 2.5.3. Simple box-type solar cooker.

which covers the black insulated box within which the raw food is kept as shown in Fig. 2.7.3. A new design of solar cooker is now available which involves a spherical reflector (concave or parabolic reflector) instead of plane mirror that has more heating effect and hence greater efficiency.

The food cooked in solar cookers is more nutritious due to slow heating. However it has the limitation that it cannot be used at night or on cloudy days. Moreover, the direction of the cooker has to be adjusted according to the direction of the sun rays.

(¿v) So1ar water heater: Et consists of an insulated box painted black from inside and having a glass lid to receive and store solar heat. Enside the box it has black painted copper coil through which cold water is made to flow in, which gets heated and flows out into a storage tank. The hot water from the storage tank fitted on roof top is then supplied through pipes into buildings like hotels and hospitals.

(v) So1ar fnrnace: Here thousands of small plane mirrors are ar- ranged in concave reflectors, all of which collect the solar heat and produce as high a temperature as 3000°C.

(v¿) So1ar power p1ant: Solar energy is harnessed on a large scale by using concave reflectors which cause boiling of water to produce steam. The steam turbine drives a generator to produce electricity. A solar power plant (70 K Watt capacity) has been installed at Gurgaon, Haryana.

■ WIND ENERGY

The high speed winds have a lot of energy in them as kinetic energy due to their motion. The driving force of the winds is the sun. The wind energy is harnessed by making use of wind mills. The blades of the wind mill keep on rotating continuously due to the force of the striking wind. The rotational motion of the blades drives a number of machines like water pumps, flour mills and electric generators. A large number of wind mills are installed in clusters called wind farms, which feed power to the utility grid and produce a large amount of electricity. These farms are ideally located in coastal regions, open grasslands or hilly regions, particularly mountain passes and ridges where the winds are strong and steady. The minimum wind speed required for satisfactory working of a wind generator is 1S km/hr.

The wind power potentia1 of onr conntry is estimated to be abont 20,000 MN, whi1e at present we are generating abont 1020 MN. The largest wind farm of our country is near Kanyakumari in Tamil Nadu generating 380 MW electricity.

Wind energy is very useful as it does not cause any air pollution. After the initial installation cost, the wind energy is very cheap. Et is believed that by the middle of the century wind power would supply more than 10% of world³s electricity.

■ HYDROPOWER

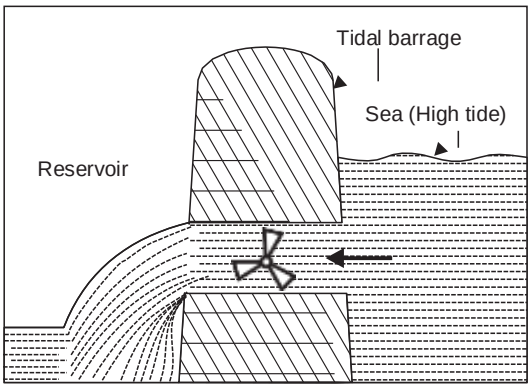
The water flowing in a river is collected by constructing a big dam where the water is stored and allowed to fall from a height. The blades of the turbine located at the bottom of the dam move with the fast moving water which in turn rotate the generator and produces electricity. We can also construct mini or micro hydel power plants on the rivers in hilly regions for harnessing the hydro energy on a small scale, but the minimum height of the water falls should be 10 metres. The hydropower potentia1 of rndia is estimated to be abont 4×10^{11} KN-honrs. Till now we have utilized only a little more than 11% of this potential.

Hydropower does not cause any pollution, it is renewable and normally the hydro power projects are multi-purpose projects helping in controlling floods, used for irrigation, navigation etc. However, big dams are often associated with a number of environmental impacts which have already been discussed in the previous section.

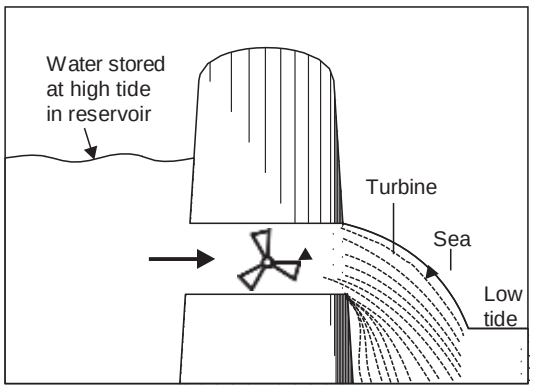
■ TIDAL ENERGY

Ocean tides produced by gravitational forces of sun and moon contain enormous amounts of energy. The ‘high tide’ and ‘1ow tide’ refer to the rise and fall of water in the oceans. A difference of several meters is required between the height of high and low tide to spin the turbines. The tidal energy can be harnessed by constructing a tidal barrage. During high tide, the sea-water flows into the reservoir of the barrage and turns the turbine, which in turn produces electricity by rotating the generators. During low tide, when the sea-level is low, the sea water stored in the barrage reservoir flows out into the sea and again turns the turbines. (Fig. 2.7.4)

There are only a few sites in the world where tidal energy can be suitably harnessed. The bay of Fundy Canada having 17-18 m high tides has a potential of 7,000 MW of power generation. The tidal mill at La Rance, France is one of the first modern tidal power mill. En Endia Gulf of Cambay, Gulf of Kutch and the Sunder bans deltas are the tidal power sites.



(a)



(d)

Fig. 2.5.4. Water flows into the reservoir to turn the turbine at high tide (*a*), and flows out from the reservoir to the sea, again turning the turbine at low tide (*b*).

■ OCEAN THERMAL ENERGY (OTE)

The energy available due to the difference in temperature of water at the surface of the tropical oceans and at deeper levels is called Ocean Thermal Energy. A difference of 20°C or more is required between surface water and deeper water of ocean for operating OTEC (Ocean Thermal Energy Conversion) power plants. The warm surface water of ocean is used to boil a liquid like ammonia. The high pressure vapours of the liquid formed by boiling are then used to turn the turbine of a generator and produce electricity. The colder water from the deeper oceans is pumped to cool and condense the vapours into liquid. Thus the process keeps on going continuously for 24 hours a day.

■

■ GEOTHERMAL ENERGY

The energy harnessed from the hot rocks present inside the earth is called geothermal energy. High temperature, high pressure steam fields exist below the earth³s surface in many places. This heat comes from the fission of radioactive material naturally present in the rocks. En some places, the steam or the hot water comes out of the ground naturally through cracks in the form of natnra1 geysers as in Manikaran, Kullu and Sohana, Haryana. Sometimes the steam or boiling water underneath the earth do not find any place to come out. We can artificially drill a hole up to the hot rocks and by putting a pipe in it makethe steam or hot water gush out through the pipe at high pressure which turns the turbine of a generator to produce electricty. En USA and New Zealand, there are several geothermal plants working successfully.

■ BIOMASS ENERGY

Biomass is the organic matter produced by the plants or animals which include wood, crop residues, cattle dung, manure, sewage, agricultural wastes etc. Biomass energy is of the following types :

(a) Energy P1antations: Solar energy is trapped by green plants through photosynthesis and converted into biomass energy. Fast grow- ing trees like cottonwood, poplar and Leucaena, non-woody herbaceous grasses, crop plants like sugarcane, sweet sorghum and sugar beet, aquatic weeds like water hyacinth and sea-weeds and carbohydrate rich potato, cereal etc. are some of the important energy plantations. They may produce energy either by burning directly or by getting converted into burnable gas or may be converted into fuels by fermentation.

(&) Petro-crops: Certain latex-containing plants like Zuphor&¿as and oil palms are rich in hydrocarbons and can yield an oil like sub- stance under high temperature and pressure. This oily material may be burned in diesel engines directly or may be refined to form gasoline. These plants are popularly known as petro-crops.

(c) Agricn1tnra1 and Urban Naste biomass: Crop residues, bagasse (sugarcane residues), coconut shells, peanut hulls, cotton stalks etc. are some of the common agricultural wastes which produce energy by burning. Animal dung, fishery and poultry waste and even human refuse are examples of biomass energy. En Brazil 30 % of electricity is obtained from burning bagasse. En rural Endia, animal dung cakes are burnt to produce heat. About 80 % of rural heat energy requirements are met by burning agricultural wastes, wood and animal dung cakes.

En rural areas these forms of waste biomass are burned in open furnaces called 'Chn1has³ which usually produce smoke and are not so efficient (efficiency is <8 %). Now improved Chulhas with tall chimney have been designed which have high efficiency and are smokeless.

The burning of plant residues or animal wastes cause air pollution and produce a lot of ash as waste residue. The burning of dung destroys essential nutrients like N and P. Et is therefore, more useful to convert the biomass into biogas or bio fuels.

■ BIOGAS

Biogas is a mixture of methane, carbon dioxide, hydrogen and hydrogen sulphide, the major constituent being methane. Biogas is produced by anaerobic degradation of animal wastes (sometimes plant wastes) in the presence of water. Anaerobic degradation means break down of organic matter by bacteria in the absence of oxygen.

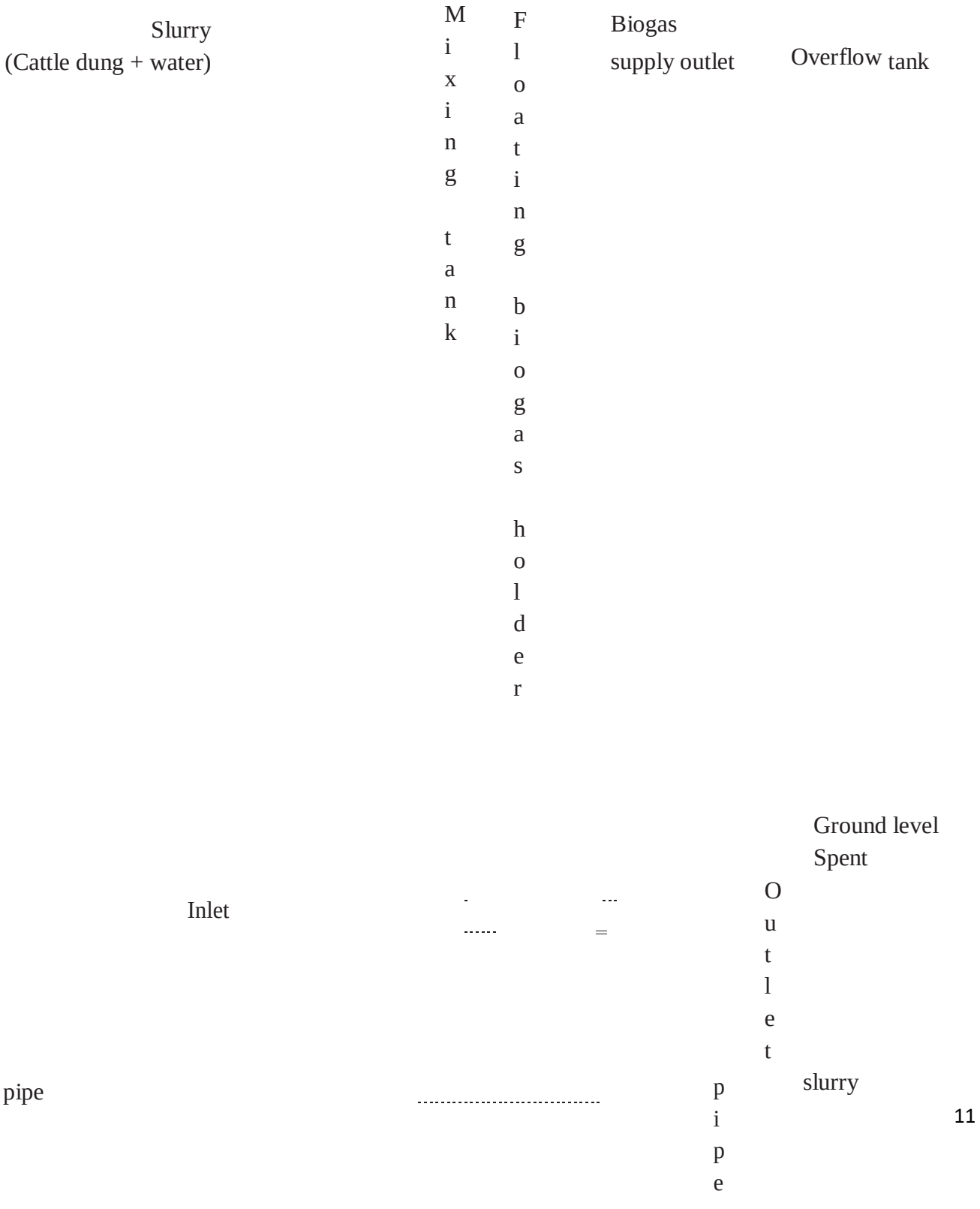
Biogas is a non-polluting, clean and low cost fuel which is very useful for rural areas where a lot of animal waste and agricultural waste are available. Endia has the largest cattle population in the world (240 million) and has tremendous potential for biogas production. From cattle dung alone, we can produce biogas of a magnitude of 22,700 Mm^3 annually. A sixty cubic feet gobar gas plant can serve the needs of one average family.

Biogas has the following main advantages : Et is clean, non- polluting and cheap. There is direct supply of gas from the plant and there is no storage problem. The sludge left over is a rich fertilizer containing bacterial biomass with most of the nutrients preserved as such. Air-tight digestion/degradation of the animal wastes is safe as it eliminates health hazards which normally occur in case of direct use of dung due to direct exposure to faecal pathogens and parasites.

Biogas plants used in our country are basically of two types:

2. Floating gas-holder type and 2. Fixed-dome type.

3. F1oating gas ho1der type biogas p1ant: This type has a well- shaped digester tank which is placed under the ground and made up of bricks. En the digester tank, over the dung slurry an inverted steel drum floats to hold the bio-gas produced. The gas holder can move which is controlled by a pipe and the gas outlet is regulated by a valve. The digester tank has a partition wall and one side of it receives the dung- water mixture through inlet pipe while the other side discharges the spent slurry through outlet pipe. (Fig 2.7.7)


Slurry
(Cattle dung + water)
Mixing tank
Floating biogas holder
Biogas supply outlet
Overflow tank
Ground level
Spent slurry
Inlet pipe
Outlet pipe
Underground

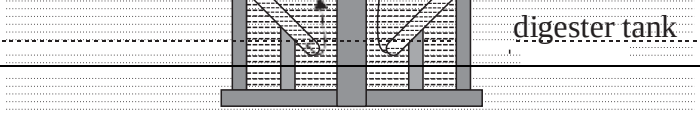
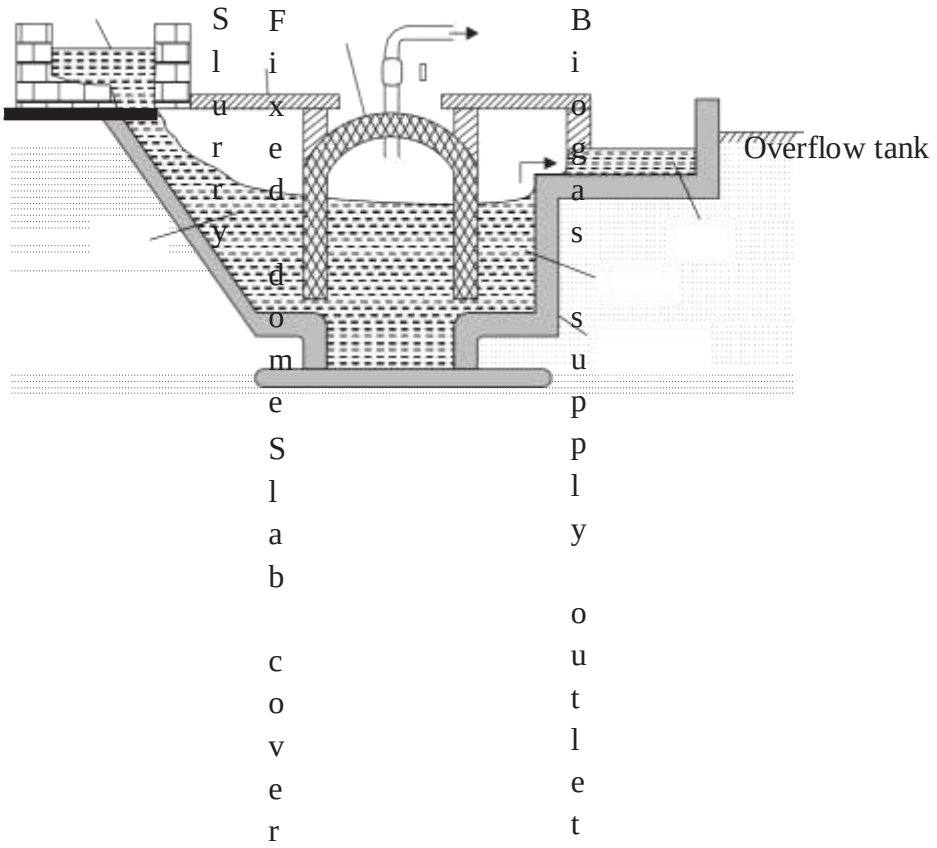


Fig. 2.5.5. Floating gas holder type biogas plant.

Sometimes corrosion of steel gas-holder leads to leakage of biogas. The tank has to be painted time and again for maintenance which increases the cost. Hence another type was designed as discussed below :

4. Fixed dome type biogas p1ant: The structure is almost similar to that of the previous type. However, instead of a steel gas-holder there is dome shaped roof made of cement and bricks. Enstead of partition- ing, here there is a single unit in the main digester but it has inlet and outlet chambers as shown in Fig 2.7.6.

Mixing tank



Ground level

Biogas

Inlet chamber

Spent slurry

Outlet chamber

Underground digester tank

Fig. 2.5.6. Fixed dome type Biogas plant.

The Ministry of Non-Conventional Energy Sources (MNES) has been promoting the Biogas Programme

in Endia. Out of the various models, the important ones used in rural set-up are KVEC Model

(Floating drum type), Janta Model (Fixed dome type), Deenbandhu Model (Fixed dome type), Pragati Model (floating drum type), Ganesh Model (KVEC type but made of bamboo and polythene sheet) and Ferro-cement digester Model (KVEC type with ferro-cement digester).

■ BIOFUELS

Biomass can be fermented to alcohols like ethanol and methanol which can be used as fuels. Ethanol can be easily produced from carbohydrate rich substances like sugarcane. Et burns clean and is non-polluting. However, as compared to petrol its calorific value is less and therefore, produces much less heat than petrol.

Gasoho1 is a common fuel used in Brazil and Zimbabwe for running cars and buses. En Endia too gasohol is planned to be used on trial basis in some parts of the country, to start with in Kanpur. Gasohol is a mixture of ethanol and gasoline.

Methano1 is very useful since it burns at a lower temperature than gasoline or diesel. Thus the bulky radiator may be substituted by sleek designs in our cars. Methanol too is a clean, non-polluting fuel.

Methanol can be easily obtained from woody plants and ethanol from grain-based or sugar-containing plants.

■ HYDROGEN AS A FUEL

As hydrogen burns in air, it combines with oxygen to form water and a large amount of energy (170 kilojoules per gram) is released. Due to its high, rather the highest calorific value, hydrogen can serve as an excel- lent fuel. Moreover, it is non-polluting and can be easily produced. Production of Hydrogen is possible by thermal dissociation, photoly- sis or electrolysis of water:

(¿) By thermal dissociation of water (at 3000°K or above) hydrogen (H_2) is produced.

(¿¿) Thermochemically, hydrogen is produced by chemical reaction
of water with some other chemicals in 2-3 cycles so that we do not need the high temperatures as in direct thermal method and ultimately H_2 is produced.

(¿¿¿) Electrolytic method dissociates water into hydrogen (H_2) and oxygen by making a current flow through it.

(¿v) Photolysis of water involves breakdown of water in the presence of sun light to release hydrogen. Green plants also have photolysis of water during photosynthesis. Efforts are underway to trap hydrogen molecule which is produced during photosynthesis.

However, hydrogen is highly inflammable and explosive in nature. Hence, safe handling is required for using H_2 as a fuel. Also, it is difficult to store and transport. And, being very light, it would have to be stored in bulk.

Presently, H_2 is used in the form of liquid hydrogen as a fuel in spaceships.

(&) Non-Renewab1e Energy Sonrces

These are the fossil fuels like coal, petroleum, natural gas and nuclear fuels. These were formed by the decomposition of the remains of plants and animals buried under the earth millions of years ago. The fuels are very precious because they have taken such a long time to be formed and if we exhaust their reserves at such a fast rate as we have been doing, ever since we discovered them, then very soon we will lose these resources forever.

■ COAL

Coal was formed 277-370 million years ago in the hot, damp regions of the earth during the carboniferous age. The ancient plants along the banks of rivers and swamps were buried after death into the soil and due to the heat and pressure gradually got converted into peat and coal over millions of years of time. There are mainly three types of coal, namely ant2racite (hard coal), bituminous (Soft coal) and lignite (brown coal). Anthracite coal has maximum carbon (90%) and calorific value (8700 kcal/kg.) Bituminous, lignite and peat contain 80, 70 and 60% carbon, respectively. Coal is the most abundant fossil fuel in the world. At t2e ¢resent rate of usage, t2e coal reserves are li#ely to last for about 200 years and if its use increases by 2% ¢er year, t2en it will last for anot2er 6S years.

Endia has about 7% of world³s coal and Endian coal is not very good in terms of heat capacity. Major coal fields in Endia are Raniganj, Jharia, Bokaro, Singrauli, and Godavari valley. The coal states of Endia are Jharkhand, Orissa, West Bengal, Madhya Pradesh, Andhra Pradesh and Maharashtra. Anthracite coal occurs only in J & K.

When coal is burnt it produces carbon dioxide, which is a greenhouse gas responsible for causing enhanced global warming. Coal also contains impurities like sulphur and therefore as it burns the smoke contains toxic gases like oxides of sulphur and nitrogen.

■ PETROLEUM

Et is the lifeline of global economy. There are 13 countries in the world having 67% of the petroleum reserves which together form the

OPEC (Organization of Petroleum exporting countries). About 1/4th of the oil reserves are in Saudi Arabia.

At the present rate of usage, the world³s crude oil reserves are estimated to get exhausted in just 40 years. Some optimists, however, believe that there are some yet undiscovered reserves. Even then the crude oil reserves will last for another 40 years or so. Crude petroleum is a complex mixture of alkane hydrocarbons. Hence it has to be purified and refined by the process of /rac5¿onal d¿s5¿lla5¿on, during which process different constituents separate out at different temperatures. We get a large variety of products from this, namely, petroleum gas, kerosene, petrol, diesel, fuel oil, lubricating oil, paraffin wax, asphalt, plastic etc.

Petroleum is a cleaner fuel as compared to coal as it burns completely and leaves no residue. Et is also easier to transport and use. That is the reason why petroleum is preferred amongst all the fossil fuels.

Liqnefied petro1enm gas (LPG): The main component of petroleum is butane, the other being propane and ethane. The petroleum gas is easily converted to liquid form under pressure as LPG. Et is odourless, but the LPG in our domestic gas cylinders gives a foul smell. This is, in fact, due to ethyl mercaptan, a foul smelling gas, added to LPG so that any leakage of LPG from the cylinder can be detected instantaneously.

Oil fields in Endia are located at Digboi (Assam), Gujarat Plains and Bombay High, offshore areas in deltaic coasts of Gadavari, Krishna, Kaveri and Mahanadi.

■ NATURAL GAS

Et is mainly composed of methane (97%) with small amounts of propane and ethane. Et is a fossil fuel. Natural gas deposits mostly accompany oil deposits because it has been formed by decomposing remains of dead animals and plants buried under the earth. Natnra1 gas is the c1eanest fossi1 fne1. Et can be easily transported through pipelines. Et has a high calorific value of about 70KJ/G and burns without any smoke.

Currently, the amount of natural gas deposits in the world are of the order of 80, 470 g m^{-3}. Russia has maximum reserves (40%), followed by Eran (14%) and USA (7%). Natural gas reserves are found in association with all the oil fields in Endia. Some new gas fields have been found in Tripura, Jaisalmer, Off-shore area of Mumbai and the Krishna Godavari Delta.

Natural gas is used as a domestic and industrial fuel. Et is used as a fuel in thermal power plants for generating electricity. Et is used as a source of hydrogen gas in fertilizer industry and as a source of carbon in tyre industry.

Compressed natnra1 gas (CNG): Et is being used as an alternative to petrol and diesel for transport of vehicles. Delhi has totally switched over to CNG where buses and auto rickshaws run on this new fuel. CNG use has greatly reduced vehicular pollution in the city.

Synthetic natnra1 gas (SNG): Et is a mixture of carbon monoxide and hydrogen. Et is a connecting link between a fossil fuel and substituted natural gas. Low grade coal is initially transformed into synthetic gas by gasification followed by catalytic conversion to methane.

■ NUCLEAR ENERGY

Nuclear energy is known for its high destructive power as evidenced from nuclear weapons. The nuclear energy can also be harnessed for providing commercial energy. Nuclear energy can be generated by two types of reactions:

(¿) Nuclear K¿ss¿on: Et is the nuclear change in which nucleus of certain isotopes with large mass numbers are split into lighter nuclei on bombardment by neutrons and a large amount of energy is released through a chain reaction as shown in Fig. 2.7.7(a).

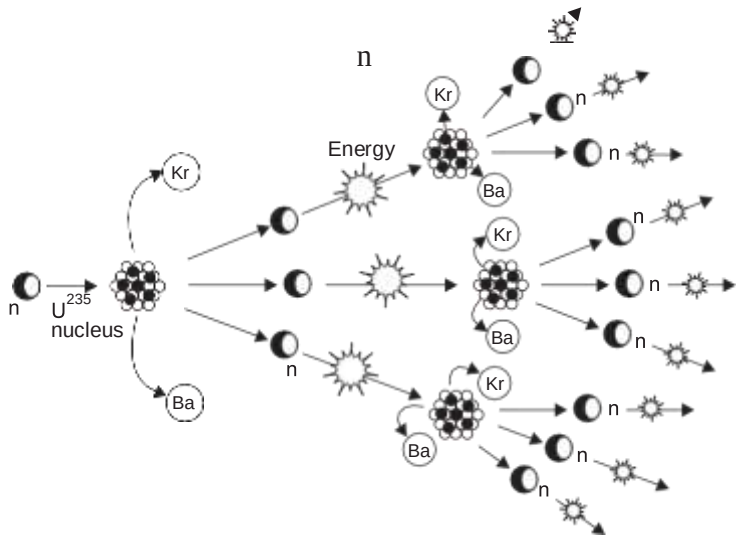


Fig. 2.5.7. (*a*) Nuclear fission—a chain reaction initiated by one neutron that bombards a Uranium (U^{235}) nucleus, releasing a huge quantity of energy, two smaller nuclei (Ba, Kr) and 3 neutrons.

$_{92}U^{237} + {}_{0}n^{1} \square\square\square {}_{36}Kr^{92} + {}_{76}Ba^{141} + 3\ {}_{0}n^{1}$ + Energy Nuclear Reactors make use of nuclear chain reaction. En order to

control the rate of fission, only 1 neutron released is allowed to strike for splitting another nucleus. Uranium-237 nuclei are most commonly used in nuclear reactors.

(¿¿) Nuclear /us¿on: Here two isotopes of a light element are forced together at extremely high temperatures (1 billion °C) until they fuse to form a heavier nucleus releasing enormous energy in the process. Et is difficult to initiate the process but it releases more energy than nuclear fission. (Fig. 2.7.7 (&))

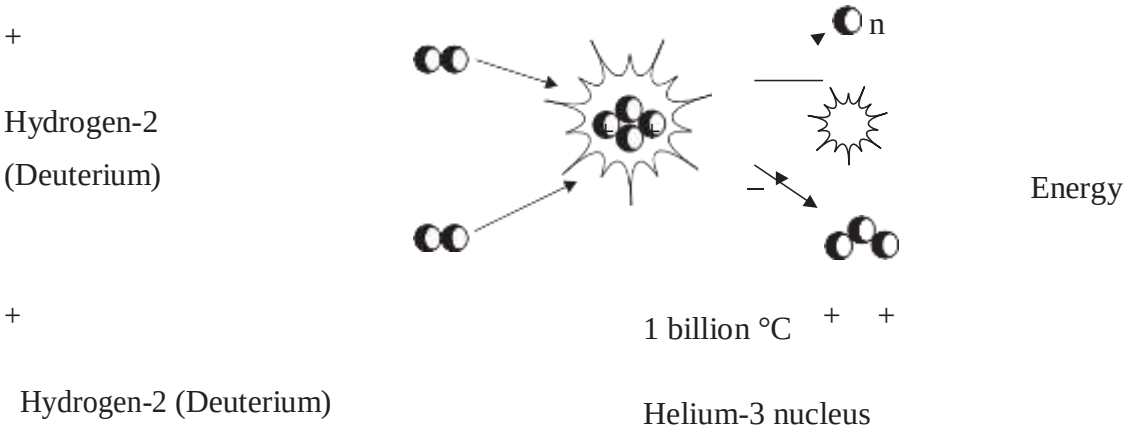


Fig. 2.5.7. (*b*) Nuclear fusion reaction between two hydrogen-2 nuclei, which take place at a very high temperature of 1 billion °C; one neutron and one fusion nucleus of helium-3 is formed along with a huge amount of energy.

$_{1}H^{2} + {}_{1}H^{2} \square\square\square {}_{3}He^{2} + {}_{0}n^{1}$ + Energy

Two hydrogen-2 (Deuterium) atoms may fuse to form the nu- cleus of Helium at 1 billion °C and release a huge amount of energy. Nuclear fusion reaction can also take place between one Hydrogen-2 (Deuterium) and one Hydrogen-3 (Tritium) nucleus at 100 million °C forming Helium-4 nucleus, one neutron and a huge amount of energy.

Nuclear energy has tremendous potential but any leakage from the reactor may cause devastating nuclear pollution. Disposal of the nuclear waste is also a big problem.

Nuclear power in Endia is still not very well developed. There are four nuclear power stations with an installed capacity of 2007 MW.

These are located at Tarapur (Maharashtra), Rana Pratap Sagar near Kota (Rajasthan), Kalpakkam (Tamil Nadu) and Narora (U.P.).

2.8. LAND RESOURCES

■ LAND AS A RESOURCE

Land is a finite and valuable resource upon which we depend for our food, fibre and fuel wood, the basic amenities of life. Soil, especially the top soil, is classified as a renewable resource because it is continuously regenerated by natural process though at a very slow rate. About 200-1000 years are needed for the formation of one inch or 2.7 cm soil, depending upon the climate and the soil type. But, when rate of erosion is faster than rate of renewal, then the soil becomes a non- renewable resource.

■ LAND DEGRADATION

With increasing population growth the demands for arable land for producing food, fibre and fuel wood is also increasing. Hence there is more and more pressure on the limited land resources which are getting degraded due to over-exploitation. Soil degradation is a real cause of alarm because soil formation is an extremely slow process as discussed above and the average annual erosion rate is 20-100 times more than the renewal rate.

Soil erosion, water-logging, salinization and contamination of the soil with industrial wastes like fly-ash, press-mud or heavy metals all cause degradation of land.

■ SOIL EROSION

The literal meaning of 'soil erosion³ is wearing away of soil. Soil ero- sion is defined as the movement of soil components, especially surface- litter and top soil from one place to another. Soil erosion results in the loss of fertility because it is the top soil layer which is fertile. Ef we look at the world situation, we find that one third of the world³s cropland is getting eroded. Two thirds of the seriously degraded lands lie in Asia and Africa.

Soil erosion is basically of two types based upon the cause of erosion:

(¿) Norma1 erosion or geo1ogic erosion: caused by the gradual removal of top soil by natural processes which bring an equilibrium between physical, biological and hydrological activities and maintain a natural balance between erosion and renewal.

(¿¿) Acce1erated erosion: This is mainly caused by anthropogenic (man-made) activities and the rate of erosion is much faster than the rate of formation of soil. Overgrazing, deforestation and mining are some important activities causing accelerated erosion.

There are two types of agents which cause soil erosion:

(¿) C1imatic agents: water and wind are the climatic agents of soil erosion. Water affects soil erosion in the form of torrential rains, rapid flow of water along slopes, run-off, wave action and melting and movement of snow.

Nater indnced soi1 erosion is of the following types:

- 32eet erosion: when there is uniform removal of a thin layer of soil from a large surface area, it is called sheet erosion. This is usually due to run-off water.
- Rill erosion: When there is rainfall and rapidly running water produces finger-shaped grooves or rills over the area, it is called rill erosion.
- Gully erosion: Et is a more prominent type of soil erosion. When the rainfall is very heavy, deeper cavities or gullies are formed, which may be U or V shaped.
- 3li¢ erosion: This occurs due to heavy rainfall on slopes of hills and mountains.
- 3tream ban# erosion: During the rainy season, when fast run- ning streams take a turn in some other direction, they cut the soil and make caves in the banks.

Nind erosion is responsible for the following three types of soil movements:

- 3altation: This occurs under the influence of direct pressure of stormy wind and the soil particles of 1-1.7 mm diameter move up in vertical direction.
- 3us¢ension: Here fine soil particles (less than 1 mm dia) which are suspended in the air are kicked up and taken away to distant places.
- 3urface cree¢: Here larger particles (7-10 mm diameter) creep over the soil surface along with wind.

(¿¿) Biotic agents: Excessive grazing, mining and deforestation are the major biotic agents responsible for soil erosion. Due to these processes the top soil is disturbed or rendered devoid of vegetation cover. So the land is directly exposed to the action of various physical forces facilitating erosion. Overgrazing accounts for 37% of the world³s soil

erosion while deforestation is responsible for 30% of the earth³s seriously eroded lands. Unsustainable methods of farming cause 28% of soil erosion.

Deforestation without reforestation, overgrazing by cattle, sur- face mining without land reclamation, irrigation techniques that lead to salt build-up, water-logged soil, farming on land with unsuitable terrain, soil compaction by agricultural machinery, action of cattle tram- pling etc make the top soil vulnerable to erosion.

Soi1 Conserration Practices

En order to prevent soil erosion and conserve the soil the following conservation practices are employed:

(¿) Conserrationa1 ti11 farming: En traditional method the land is ploughed and the soil is broken up and smoothed to make a planting surface. However, this disturbs the soil and makes it susceptible to ero- sion when fallow (i.e. without crop cover). Conservational till farm- ing, popularly known as no-ti11-farming causes minimum disturbance to the top soil. Here special tillers break up and loosen the subsurface soil without turning over the topsoil. The tilling machines make slits in the unploughed soil and inject seeds, fertilizers, herbicides and a little water in the slit, so that the seed germinates and the crop grows suc- cessfully without competition with weeds.

(¿¿) Contonr farming: On gentle slopes, crops are grown in rows across, rather than up and down, a practice known as contour farming. Each row planted horizontally along the slope of the land acts as a small dam to help hold soil and slow down loss of soil through run-off water.

(¿¿¿) Terracing: Et is used on still steeper slopes are converted into a series of broad terraces which run across the contour. Terracing retains water for crops at all levels and cuts down soil erosion by controlling run off. En high rainfall areas, ditches are also provided behind the terrace to permit adequate drainage (Plate E, a).

(¿v) Strip cropping: Here strips of crops are alternated with strips of soil saving covercrops like grasses or grass-legume mixture. Whatever run-off comes from the cropped soil is retained by the strip of cover- crop and this reduces soil erosion. Nitrogen fixing legumes also help in restoring soil fertility (Plate E, &).

Plate I(a) Terrace farming Plate I(b) Strip cropping

(v¿) A11ey cropping: Et is a form of inter-cropping in which crops are planted between rows of trees or shrubs. This is also called Agro forestry. Even when the crop is harvested, the soil is not fallow because trees and shrubs still remain on the soil holding the soil particles and prevent soil erosion (Plate E, c).

Nind breaks or she1terbe1ts: They help in reducing erosion caused by strong winds. The trees are planted in long rows along the cultivated land boundary so that wind is blocked. The wind speed is substantially reduced which helps in preventing wind erosion of soil (Plate E, d).

Thus, soil erosion is one of the world³s most critical problems and, if not slowed, will seriously reduce

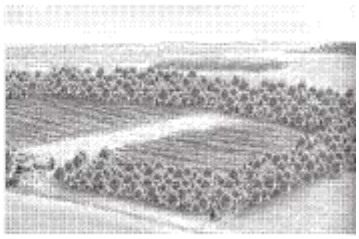


Plate I(c) Alley cropping Plate I(d) Shelter belt

agricultural and forestry production, and degrade the quality of aquatic ecosystems as well due to increased siltation. Soil erosion, is in fact, a gradual process and very often the cumulative effects becomes visible only when the damage has already become irreversible. The best way to control soil erosion is to maintain adequate vegetational cover over the soil.

Water Logging

En order to provide congenial moisture to the growing crops, farmers usually apply heavy irrigation to their farmland. Also, in order to leach down the salts deeper into the soil, the farmer provides more irrigation

water. However, due to inadequate drainage and poor quality irrigation water there is accumulation of water underground and gradually it forms a continuous column with the water table. We call these soils as waterlogged soils which affect crop growth due to inhibition of exchange of gases. The pore-spaces between the soil particles get fully drenched with water through the roots.

Water logging is most often associated with salinity because the water used for irrigation contains salts and the soils get badly degraded due to erroneous irrigation practices. The damages caused by some major irrigation projects is shown is Table 2.6.1.

Tab1e 2.6.1. Nater 1ogging and sa1inisation cansed dne to some irrigation projects in rndia

rrrigation Project	State	Area affected (thonsand hectare

		s)	
E n d i r a G a n d h i C a n a l	R a j a s t h a n		
G a n d a k	B i h a r , G u j		

	arat		
Chambal	M.P., Rajasthan		
Ram Ganga	U.P.		
Sri Ram Sagar	Andhra Pradesh		

Source : B.K. Garg and E.C. Gupta (1997).*

An estimated loss of Rs. 10,000 million per annum occurs due to water-logging and salinity in Endia. Et is a

startling fact because the cost of development of the irrigation projects is very high and in the long run they cause problems like water logging and salinity thereby sharply reducing soil fertility.

■ LANDSLIDES

Various anthropogenic activities like hydroelectric projects, large dams, reservoirs, construction of roads and railway lines, construction of buildings, mining etc are responsible for clearing of large forested areas. Earlier there were few reports of landslides between Rishikesh and Byasi on Badrinath Highway area. But, after the highway was constructed, 17 landslides occurred in a single year. During construction of roads,

mining activities etc. huge portions of fragile mountainous areas are cut or destroyed by dynamite and thrown into adjacent valleys and streams. These land masses weaken the already fragile mountain slopes and lead to landslides. They also increase the turbidity of various nearby streams, thereby reducing their productivity.

■ DESERTIFICATION

Desertification is a process whereby the productive potential of arid or semiarid lands falls by ten percent or more. Moderate desertification is 10-27% drop in productivity, severe desertification causes 27-70% drop while very severe desertification results in more than 70% drop in productivity and usually creates huge gullies and sand dunes. Desertification leads to the conversion of rangelands or irrigated croplands to desert like conditions in which agricultural productivity falls. Desertification is characterized by devegetation and loss of vegetal over, depletion of groundwater, salinization and severe soil erosion. Desertification is not the literal invasion of desert into a non-desert area. Et includes degradation of the ecosystems within as well as outside the natural deserts. The Sonoran and Chihuahuan deserts are about a million years old, yet they have become more barren during the last 100 years. So, further desertification has taken place within the desert.

Canses of Desertification: Formation of deserts may take place due to natural phenomena like climate change or may be due to abusive use of land. Even the climate change is linked in many ways to human activities. The major anthropogenic activities responsible for desertification are as follows:

(a) Deforestation: The process of denuding and degrading a forested land initiates a desert producing cycle that feeds on itself. Since there is no vegetation to hold back the surface run-off, water drains off quickly before it can soak into the soil to nourish the plants or to replenish the groundwater. This increases soil erosion, loss of fertility and loss of water.

(&) Orergrazing: The regions most seriously affected by desertification are the cattle producing areas of the world. This is because the increasing cattle population heavily graze in grasslands or forests and as a result denude the land area. When the earth is denuded, the microclimate near the ground becomes inhospitable to seed germination. The dry barren land becomes loose and more prone to soil erosion. The top fertile layer is also lost and thus plant growth is badly hampered in such soils. The dry barren land reflects more of the

sun³s heat, changing wind patterns, driving away moisture laden clouds leading to further desertification.

(c) Mining and qnarrying: These activities are also responsible for loss of vegetal cover and denudation of extensive land areas leading to desertification. Deserts are found to occur in the arid and semi-arid areas of all the continents . During the last 70 years about 900 million hectares of land have undergone desertification over the world. This problem is especially severe in Sahel region, just south of the Sahara in Africa. Et is further estimated that if desertification continues at the present rate, then by 2010, it will affect such lands which are presently occupied by 20% of the human population.

Amongst the most badly affected areas are the sub Saharan Africa, the Middle East, Western Asia, parts of Central and South America, Australia and the Western half of the United States.

Et is estimated that in the last 70 years, human activities have been responsible for desertification of land area equal to the size of Brazil. The UNEP estimates suggest that if we don³t make sincere efforts now then very soon 63% of rangelands, 60% of rain-fed croplands and 30% of irrigated croplands will suffer from desertification on a worldwide scale, adding 60,000 Km^2 of deserts every year.

■ CONSERVATION OF NATURAL RESOURCES: ROLE OF AN INDIVIDUAL

Different natural resources like forests, water, soil, food, mineral and energy resources play a vital role in the development of a nation. However, overuse of these resources in our modern society is resulting in fast depletion of these resources and several related problems. Ef we want our mankind to flourish there is a strong need to conserve these natural resources.

While conservation efforts are underway at National as well as International level, the individual efforts for conservation of natural resources can go a long way. Environment belongs to each one of us and all of us have a responsibility to contribute towards its conserva- tion and protection. “Small droplets of water together form a big ocean”. Similarly, with our small individual efforts we can together help in con- serving our natural resources to a large extent. Let us see how can individuals help in conservation of different resources.

Conserre Nater

- Don³t keep water taps running while brushing, shaving, wash- ing or bathing.

- En washing machines fill the machine only to the level required for your clothes.
- Enstall water-saving toilets that use not more than 6 liters per flush.
- Check for water leaks in pipes and toilets and repair them promptly. A small pin-hole sized leak will lead to the wastage of 640 liters of water in a month.
- Reuse the soapy water of washings from clothes for washing off the courtyards, driveways etc.
- Water the plants in your kitchen-garden and the lawns in the evening when evaporation losses are minimum. Never water the plants in mid-day.
- Use drip irrigation and sprinkling irrigation to improve irrigation efficiency and reduce evaporation.
- Enstall a small system to capture rain water and collect normally wasted used water from sinks, cloth-washers, bath- tubs etc. which can be used for watering the plants.
- Build rain water harvesting system in your house. Even the President of Endia is doing this.

Conserre energy

- Turn off lights, fans and other appliances when not in use.
- Obtain as much heat as possible from natural sources. Dry the clothes in sun instead of drier if it is a sunny day.
- Use solar cooker for cooking your food on sunny days which will be more nutritious and will cut down on your LPG ex- penses.
- Build your house with provision for sunspace which will keep your house warmer and will provide more light.
- Grow deciduous trees and climbers at proper places outside your home to cut off intense heat of summers and get a cool breeze and shade. This will cut off your electricity charges on coolers and air-conditioners. A big tree is estimated to have a cooling effect equivalent to five air conditioners. The decidu- ous trees shed their leaves in winter. Therefore they do not put any hindrance to the sunlight and heat.
- Drive less, make fewer trips and use public transportations whenever possible. You can share by joining a car-pool if you regularly have to go to the same place.

- Add more insulation to your house. During winter close the windows at night. During summer close the windows during days if using an A.C. Otherwise loss of heat would be more, consuming more electricity.
- Enstead of using the heat convector more often wear adequate woolens.
- Recycle and reuse glass, metals and paper.
- Try riding bicycle or just walk down small distances instead of using your car or scooter.
- Lower the cooling load on an air conditioner by increasing the thermostat setting as 3-7 % electricity is saved for every one degree rise in temperature setting.

Protect the soi1

- While constructing your house, don³t uproot the trees as far as possible. Plant the disturbed areas with a fast growing native ground cover.
- Grow different types of ornamental plants, herbs and trees in your garden. Grow grass in the open areas which will bind the soil and prevent its erosion.
- Make compost from your kitchen waste and use it for your kitchen-garden or flower-pots.
- Do not irrigate the plants using a strong flow of water, as it would wash off the soil.
- Better use sprinkling irrigation.
- Use green manure and mulch in the garden and kitchen-garden which will protect the soil.
- Ef you own agricultural fields, do not over-irrigate your fields without proper drainage to prevent water logging and salinisation.
- Use mixed cropping so that some specific soil nutrients do not get depleted.

Promote Snstainab1e Agricn1tnre

- Do not waste food. Take as much as you can eat.
- Reduce the use of pesticides.
- Fertilize your crop primarily with organic fertilizers.
- Use drip irrigation to water the crops.
- Eat local and seasonal vegetables. This saves lot of energy on transport, storage and preservation.

- Control pests by a combination of cultivation and biological control methods.

■ EQUITABLE USE OF RESOURCES FOR SUSTAINABLE LIFE STYLE

There is a big divide in the world as North and South, the more developed countries (MDC³s) and less developed countries (LDC³s), the haves and the have nots. The less developed does not mean that they are backward as such, they are culturally very rich or even much more developed, but economically they are less developed. The gap between the two is mainly because of population and resources.

The MDC³s have only 22% of world³s population, but they use 88% of its natural resources, 73% of its energy and command 87% of its income. En turn, they contribute a very big proportion to its pollution. These countries include USA, Canada, Japan, the CES, Australia , New Zealand and Western European Countries. The LDC³s, on the other hand, have very low or moderate industrial growth, have 78% of the world³s population and use about 12% of natural resources and 27% of energy. Their income is merely 17% of global income. The gap between the two is increasing with time due to sharp increase in population in the LDC³s. The rich have grown richer while the poor have stayed poor or gone even poorer.

As the rich nations are developing more, they are also leading to more pollution and sustainability of the earth³s life support system is under threat. The poor nations, on the other hand, are still struggling hard with their large population and poverty problems. Their share of resources is too little leading to unsustainability.

As the rich nations continue to grow, they will reach a limit. Ef they have a growth rate of 10 % every year, they will show 1024 times increase in the next 70 years. Will this much of growth be sustainable? The answer is 'No³ because many of our earth³s resources are limited and even the renewable resources will become unsustainable if their use exceeds their regeneration.

Thus, the solution to this problem is to have more equitable distribution of resources and wealth. We cannot expect the poor countries to stop growth in order to check pollution because development brings employment and the main problem of these countries is to tackle poverty. A global consensus has to be reached for more balanced distribution of the basic resources like safe drinking water, food, fuel etc. so that the poor in the LDC³s are at least able to sustain their life. Unless they are provided with such basic resources,

we cannot think of rooting out the problems related to dirty, unhygienic, polluted, disease infested settlements of these people-which contribute to unsustainability.

Thus, the two basic causes of unsustainability are over population in poor countries who have under consumption of resources and over consumption of resources by the rich countries, which generate wastes. En order to achieve sustainable life styles it is desirable to achieve a more balanced and equitable distribution of global resources and income to meet everyone³s basic needs.

The rich countries will have to lower down their consumption levels while the bare minimum needs of the poor have to be fulfilled by providing them resources. A fairer sharing of resources will narrow downthe gap between the rich and the poor and will lead to sustainable development for all and not just for a privileged group.

UNIT
2

Ecosystems

■ CONCEPT OF ECOSYSTEM

Various kinds of life supporting systems like the forests, grasslands, oceans, lakes, rivers, mountains, deserts and estuaries show wide variations in their structural composition and functions. However, they all are alike in the fact that they consist of living entities interacting with their surroundings exchanging matter and energy. How do these different units like a hot desert, a dense evergreen forest, the Antarctic Sea or a shallow pond differ in the type of their flora and fauna, how do they derive their energy and nutrients to live together, how do they influence each other and regulate their stability are the questions that are answered by Ecology.

The term Ecology was coined by Earnst Haeckel in 1869. Et is derived from the Greek words O¿#os- home + logos- study. So eco1ogy dea1s with the stndy of organisms in their natnra1 home interacting with their snrronndings. The surroundings or environment consists of other living organisms (biotic) and physical (abiotic) components. Modern ecologists believe that an adequate definition of ecology must specify some unit of study and one such basic unit described by Tansley (1937) was ecosystem. An ecosystem is a gronp of biotic commnnities of species interacting with one another and with their non-1iring enrironment exchanging energy and matter. Now eco1ogy is often defined as "the stndy of ecosystems".

An ecosystem is an integrated unit consisting of interacting plants, animals and microorganisms whose survival depends upon the maintenance and regulation of their biotic and abiotic structures and functions. The ecosystem is thus, a unit or a system which is composed of a number of subunits, that are all directly or indirectly linked with each other. They may be freely exchanging energy and matter from outside—an open ecosys5em or may be isolated from outside—a closed ecosys5em.

■ ECOSYSTEM CHARACTERISTICS

Ecosystems show large variations in their size, structure, composition etc. However, all the ecosystems are characterized by certain basic struc- tural and functional features which are common.

■ STRUCTURAL FEATURES

Composition and organization of biological communities and abiotic components constitute the structure of an ecosystem.

I. Biotic Structure

The plants, animals and microorganisms present in an ecosystem form the biotic component. These organisms have different nutritional be- haviour and status in the ecosystems and are accordingly known as 9roducers or ✓onsumers, based on how do they get their food.

(a) Prodncers: They are mainly the green plants, which can synthesize their food themselves by making use of carbondioxide present in the air and water in the presence of sunlight by involving chlorophyll, the green pigment present in the leaves, through the process of photosynthesis. They are also known as photo antotrophs (auto=self; troph=food, photo=light).

There are some microorganisms also which can produce organic matter to some extent through oxidation of certain chemicals in the absence of sunlight. They are known as chemosynthetic organisms or chemo-antotrophs. For instance in the ocean depths, where there is no sunlight, chemoautotrophic sulphur bacteria make use of the heat generated by the decay of radioactive elements present in the earth³s core and released in ocean³s depths. They use this heat to convert dissolved hydrogen sulphide (H_2S) and carbon dioxide (CO_2) into organic compounds.

(&) Consnmers: All organisms which get their organic food by feeding upon other organisms are called consumers, which are of the following types:

(¿) Kerbivores (plant eaters): They feed directly on producers and hence also known as pr¿mary consumers. e.g. rabbit, insect, man.

(¿¿) Carnivores (meat eaters): They feed on other consumers. Ef they feed on herbivores they are called secondary consumers (e.g. frog) and if they feed on other carnivores (snake, big fish etc.) they are known as 5er5¿ary carn¿vores/consumers.

(¿¿¿) Omnivores: They feed on both plants and animals. e.g. humans, rat, fox, many birds.

(¿v) Detritivores (Detritus feeders or 3a¢rotro¢2s): They feed on the parts of dead organisms, wastes of living organisms, their cast- offs and partially decomposed matter e.g. beetles, termites, ants, crabs, earthworms etc.

(c) Decomposers: They derive their nutrition by breaking down the complex organic molecules to simpler organic compounds and ul- timately into inorganic nutrients. Various bacteria and fungi are decomposers.

En all the ecosystems, this biotic structure prevails. However, in some, it is the primary producers which predominate (e.g. in forests, agroecosystems) while in others the decomposers predominate (e.g. deep ocean).

II. Abiotic Structure

The physical and chemical components of an ecosystem constitute its abiotic structure. Et includes climatic factors, edaphic (soil) factors, geographical factors, energy, nutrients and toxic substances.

(a) P2ysical factors: The sunlight and shade, intensity of solar flux, duration of sun hours, average temperature, maximum-minimum temperature, annual rainfall, wind, latitude and altitude, soil type, water availability, water currents etc. are some of the important physical features which have a strong influence on the ecosystem.

We can clearly see the striking differences in solar flux, temperature and precipitation (rainfall, snow etc.) pattern in a desert ecosystem, in a tropical rainforest and in tundra ecosystem.

(&) C2emical factors: Availability of major essential nutrients like carbon, nitrogen, phosphorus, potassium, hydrogen, oxygen and sulphur, level of toxic substances, salts causing salinity and various organic substances present in the soil or water largely influence the functioning of the ecosystem.

All the biotic components of an ecosystem are influenced by the abiotic components and vice versa, and they are linked together through energy flow and matter cycling as shown diagrammatically in Fig. 3.1.

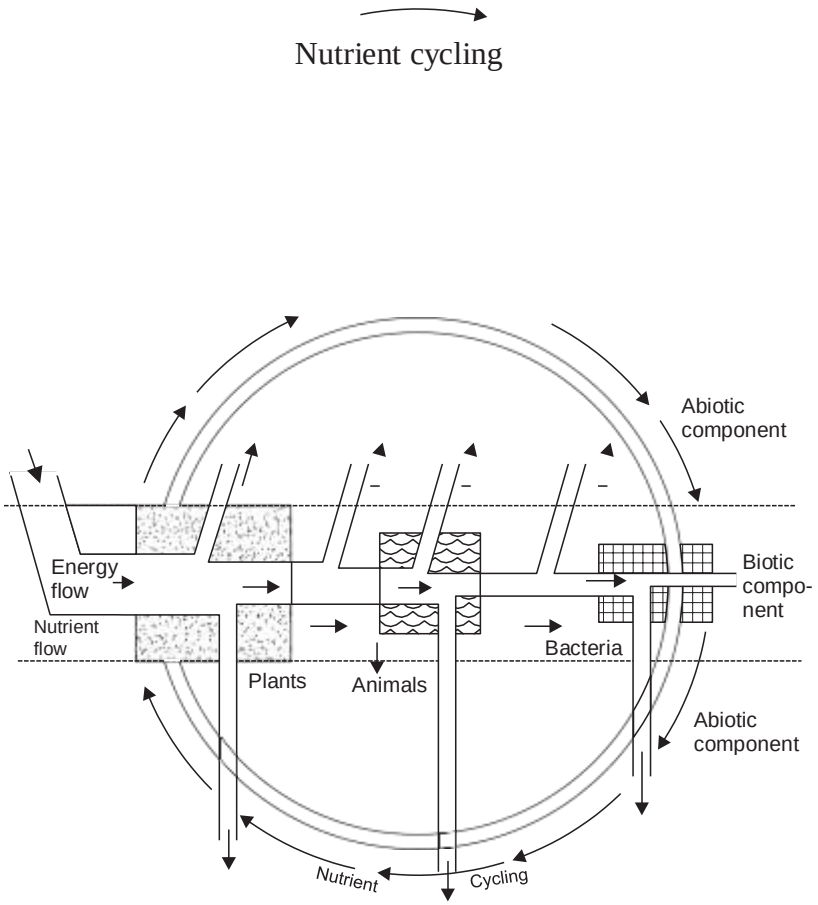


Fig. 3.1. Nutrient cycling and energy flow mediated through food- chain. The flow of energy is unidirectional while the nutrients move in a cyclic manner from the abiotic to biotic (food chain) to abiotic and so on.

■ FUNCTIONAL ATTRIBUTES

Every ecosystem performs under natural conditions in a systematic way. Et receives energy from the sun and passes it on through various biotic components and in fact, all life depends upon this flow of energy. Besides energy, various nutrients and water are also required for life processes which are exchanged by the biotic components within themselves and with their abiotic components within or outside the ecosystem. The biotic components also regulate themselves in a very systematic manner and show mechanisms to encounter some degree of environmental stress. The major functional attributes of an ecosystems are as follows:

(¿) Food chain, food webs and trophic structure (¿¿) Energy flow

(¿¿¿) Cycling of nutrients (Biogeochemical cycles) (¿v) Primary and Secondary production

(v) Ecosystem development and regulation

■ TROPHIC STRUCTURE

The structure and functions of ecosystems are very closely related and influence each other so intimately that they need to be studied together. The flow of energy is mediated through a series of feeding relation- ships in a definite sequence or pattern which is known as food chain. Nutrients too move along the food chain. The producers and consum- ers are arranged in the ecosystem in a definite manner and their inter- action along with population size are expressed together as trophic strnctnre. Each food level is known as trophic 1ere1 and the amount of living matter at each trophic level at a given time is known as standing crop or standing biomass.

Before we study about energy flow or nutrient cycling, we must learn about the food-chains, that provide the path through which the flow of energy and matter take place in ecosystem.

■ FOOD CHAINS

The seqnence of eating and being eaten in an ecosystem is known as food chain. All organisms, living or dead, are potential food for some other organism and thus, there is essentially no waste in the functioning of a natural ecosystem. A caterpillar eats a plant leaf, a sparrow eats the caterpillar, a cat or a hawk eats the sparrow and when they all die, they are all consumed by microorganisms like bacteria or fungi (decomposers) which break down the organic matter and convert it into simple inorganic substances that can again be used by the plants- the primary producers.

Some common examples of simple food chains are:

- Grass □ grasshopper □ Frog □ Snake □ Hawk (Grassland ecosystem)
- Phytoplanktons □ water fleas □ small fish □ Tuna (Pond ecosystem)
- Lichens □ reindeer □ Man (Arctic tundra)

Each organism in the ecosystem is assigned a feeding level or trophic level depending on its nutritional status. Thus, in the grassland food chain, grasshopper occupies the Est trophic level, frog the EEnd and snake and hawk occupy the EEErd and the EVth trophic levels, re- spectively. The decomposers consume the dead matter of all these trophic levels. En nature, we come across two major types of food chains:

r. Grazing food chain: Et starts with green plants (primary pro- ducers) and culminates in carnivores. All the examples cited above show this type of food chain. Another example could be

Grass □ Rabbit □ Fox

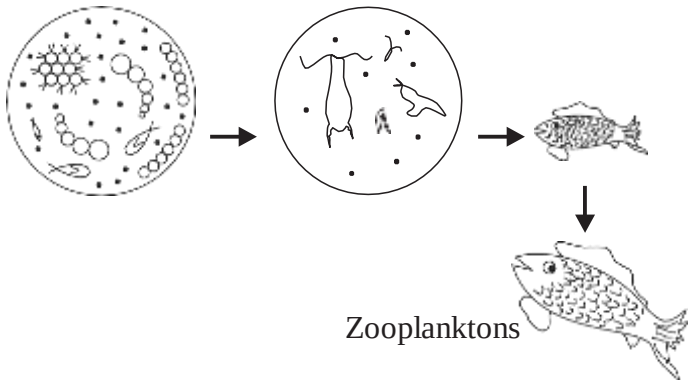


Fig. 3.2. A grazing food chain in a pond ecosystem.

rr. Detritns food chain: Et starts with dead organic matter which the detritivores and decomposers consume. Partially decomposed dead organic matter and even the decomposers are consumed by detritivores and their predators. An example of the detritus food chain is seen in a Mangrove (estuary).

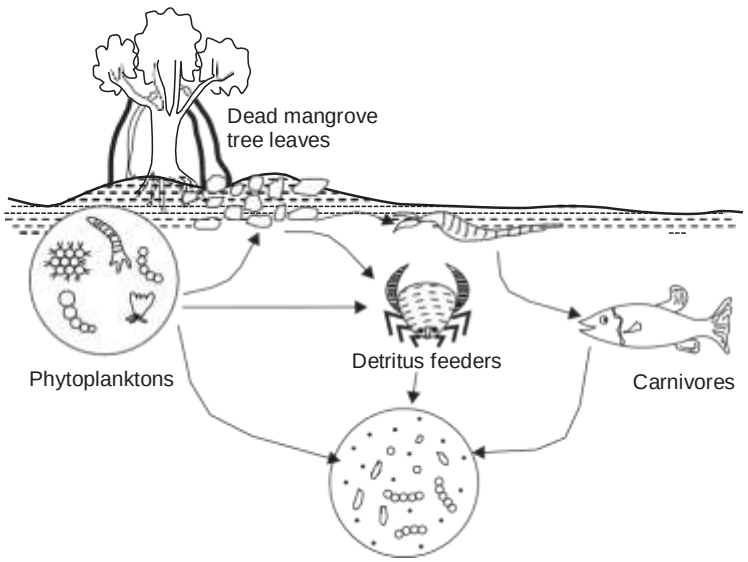


Fig. 3.3. A detritus food chain in an estuary based on dead leaves of mangrove trees.

Here, a large quantity of leaf material falls in the form of litter into the water. The leaf fragments are eaten by saprotrophs. (Saprotrophs are those organisms which feed on dead organic matter). These fallen leaves are colonized by small algae, which are also consumed by the saprotrophs or detritivores consisting of crabs, mollusks, shrimps, insect larvae, nematodes and fishes. The detritivores are eaten by small carnivorous fishes, which is turn are eaten by large carnivorous fishes.

Leaf litter □ algae □ crabs □ small carnivorous fish □ large carnivorous fish (Mangrove ecosystem)

Dead organic matter □ fungi □ bacteria (Forest ecosystem)

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

■ FOOD WEB

Food chains in ecosystems are rarely found to operate as isolated linear sequences. Rather, they are found to be interconnected and usually form a complex network with several linkages and are known as food webs. Thus, food web is a network of food chains where different types of organisms are connected at different trophic 1ere1s, so that there are a nnmber of options of eating and being eaten at each trophic 1ere1.

Fig. 3.4 illustrates an example of a food-web in the unique Antarctic Ecosystem. This is representing the total ecosystem including the Antarctic sea and the continental land. The land does not show any higher life forms of plants. The only species are that of some algae, lichens and mosses. The animals include penguins and snow petrel which depend upon the aquatic chain for their food energy.

En a tropical region, on the other hand, the ecosystems are much more complex. They have a rich species diversity and therefore, the food webs are much more complex.

Why nature has evolved food webs in ecosystems instead of sim- ple linear food chains? This is because food webs give greater stability to the ecosystem. En a linear food chain, if one species becomes extinct or one species suffers then the species in the subsequent trophic levels are also affected. En a food web, on the other hand, there are a number of options available at each trophic level. So if one species is affected, it does not affect other trophic levels so seriously.

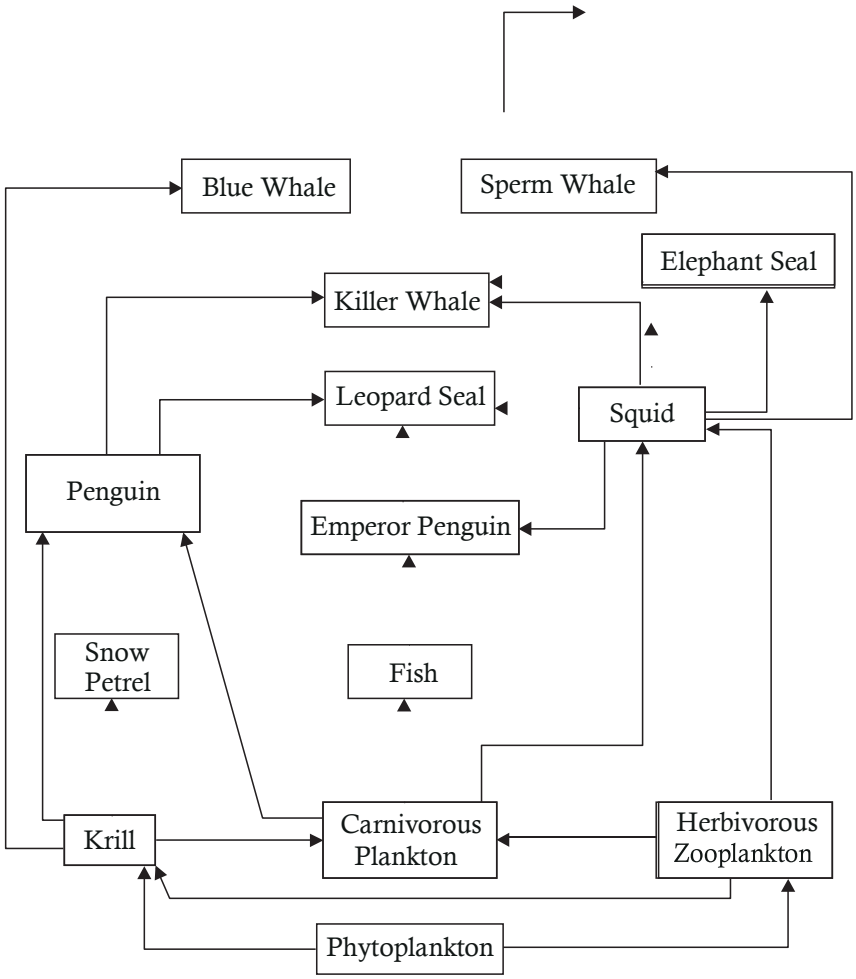


Fig. 3.4. A simplified food web in Antarctic ecosystem.

Just consider the simple food chains of arctic tundra ecosystem: Cladonia □ Reindeer □ Man
Grass □ Caribou □ Wolf

Ef due to some stress, the population of reindeer or Caribou falls, it will leave little option for man or wolf to eat from the ecosystem. Had there been more biodiversity, it would have led to complex food web giving the ecosystem more stability.

Significance of food chains and food webs

- Food chains and food webs play a very significant role in the ecosystem because the two most important functions of en~ ergy flow and nutrient cycling ta#e ¢lace t2roug2 t2em.

- The food chains also help in maintaining and regulating the population size of different animals and thus, help maintain the ecological balance.
- Food chains show a unique property of bio1ogica1 magnifica- tion of some chemicals. There are several pesticides, heavy metals and other chemicals which are non-biodegradable in nature. Such chemicals are not decomposed by microorgan- isms and they keep on passing from one trophic level to an- other. And, at each successive trophic level, they keep on in- creasing in concentration. This phenomenon is known as biomagnification or biological magnification.

CASE STUDY

A bni1d-np of DDT concentration : A striking case of biomagnification of DDT (a broad range insecticide) was observed when some birds like Osprey were found to suffer a sharp decline in their population. The young ones of these birds were found to hatch out in premature condition leading to their death. This was later found to be due to bio-magnification of DDT through the food chain. DDT sprayed for pest control was in very low concentration, but its concentration increased along the food chain through phytoplanktons to zooplanktons and then to fish which was eaten by the birds. The concentration of DDT was magnified several thousand times in the birds which caused thinning of shells in the birds³ eggs, causing death of the young ones.

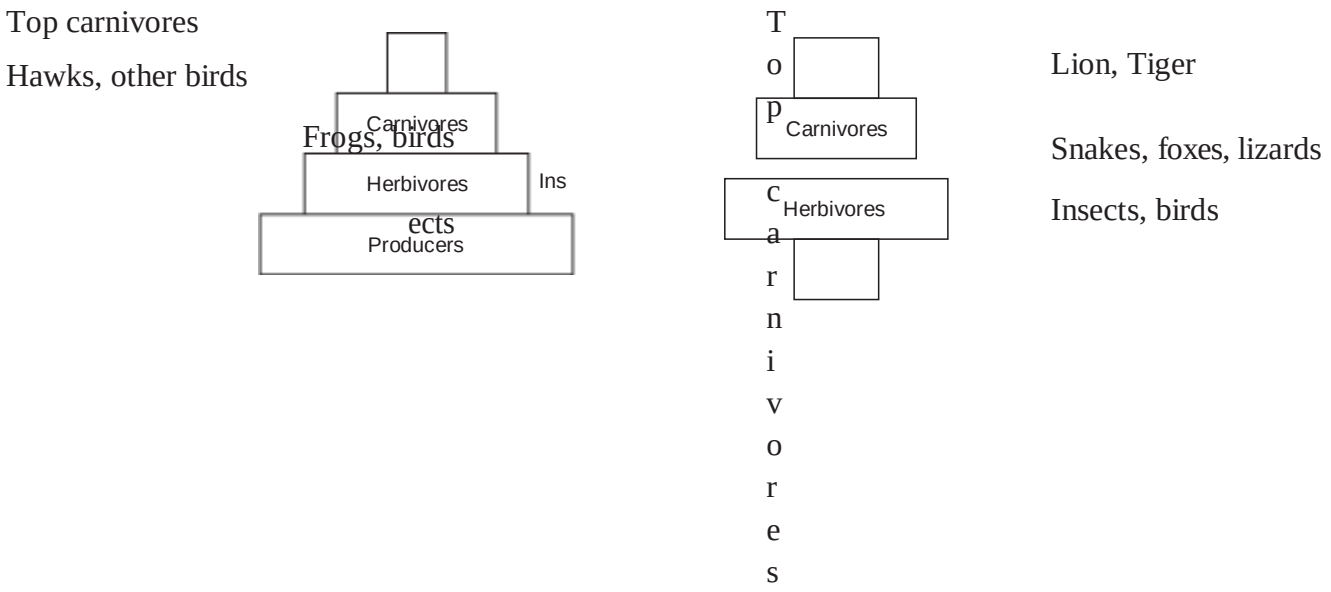
Et becomes very clear from the above instance that the animals occupying the higher trophic levels are at a greater risk of biomagnification of toxic chemicals. Human beings consuming milk, eggs and meat are at a higher trophic level. So, we have to stop indiscriminate use of pesticides and heavy metals if we wish to save ourselves from their biologically magnified toxic levels.

■ ECOLOGICAL PYRAMIDS

Graphic representation of trophic strnctnre and fnnction of an ecosys- tem, starting with prodncers at the base and snccessire trophic 1ere1s forming the apex is knows as an eco1ogica1 pyramid. Ecological pyra- mids are of three types:

Pyramid of nnmbers: Et represents the number of individual organisms at each trophic level. We may have upr¿gh5 or ¿nver5ed pyramid

of numbers, depending upon the type of ecosystem and food chain as shown in Fig. 3.7. A grassland ecosystem (Fig. 3.7a) and a pond ecosystem show an upright pyramid of numbers. The producers in the grasslands are grasses and that in a pond are phytoplanktons (algae etc.), which are small in size and very large in number. So the producers form a broad base. The herbivores in a grassland are insects while tertiary carnivores are hawks or other birds which are gradually less and less in number and hence the pyramid apex becomes gradually narrower forming an upright pyramid. Similar is the case with the herbivores, carnivores and top carnivores in pond which decrease in number at higher trophic levels.



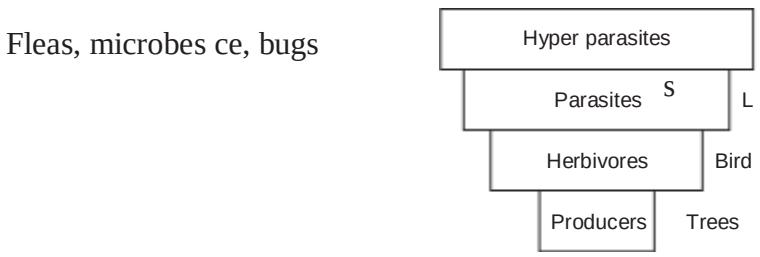


Fig. 3.5. Pyramid of numbers (*a*) grassland (*b*) forest (*c*) Parasitic food chain.

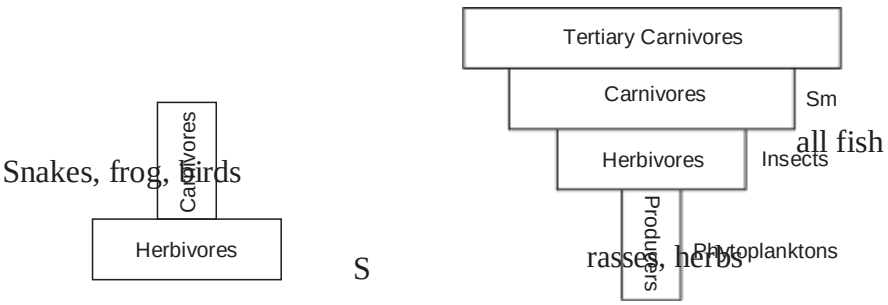
En a forest ecosystem, big trees are the producers, which are less in number and hence form a narrow base. A larger number of herbivores including birds, insects and several species of animals feed upon the trees (on leaves, fruits, flowers, bark etc.) and form a much broader middle level. The secondary consumers like fox, snakes, lizards etc. are less in number than herbivores while top carnivores like lion, tiger etc. are still

smaller in number. So the pyramid is narrow on both sides and broader in the middle (Fig. 3.7 &).

Parasitic food chain shows an inverted pyramid of number. The producers like a few big trees harbour fruit eating birds acting like

herbivores which are larger in number. A much higher number of lice, bugs etc. grow as parasites on these birds while a still greater number of hyperparasites like bugs, fleas and microbes feed upon them, thus making an inverted pyramid (Fig. 3.7 c).

Pyramid of biomass: Et is based upon the total biomass (dry matter) at each trophic level in a food chain. The pyramid of biomass can also be upr¿gh5 or ¿nver5ed. Fig. 3.6 (a, &) show pyramids of biomass in a forest and an aquatic ecosystem. The pyramid of biomass in a forest is upright in contrast to its pyramid of numbers. This is because the producers (trees) accumulate a huge biomass while the consumers³ total biomass feeding on them declines at higher trophic levels, resulting in broad base and narrowing top.



Big fish

Sm

all fish

Insects

Snakes, frog, birds

Carnivores

Herbivores

rasses, herbs

(a)

Squirrel, rabbit, insects

Producers

Grasses

(b)

Fig. 3.6. Pyramid of biomass (*a*) Grassland (*b*) Pond.

The pond ecosystem shows an inverted pyramid of biomass (Fig. 3.6 &). The total biomass of producers (phytoplanktons) is much less as compared to herbivores (zooplanktons, insects), Carnivores (Small fish) and tertiary carnivores (big fish). Thus the pyramid takes an inverted shape with narrow base and broad apex.

Pyramid of Energy: The amount of energy present at each trophic level is considered for this type of pyramid. Pyramid of energy gives the best representation of the trophic relationships and it is always upr¿gh5.

At every successive trophic level, there is a huge loss of energy (about 90%) in the form of heat, respiration etc. Thus, at each next higher level only 10% of the energy passes on. Hence, there is a sharp decline in energy level of each successive trophic level as we move from producers to top carnivores. Therefore, the pyramid of energy is always upright as shown in Fig. 3.7.

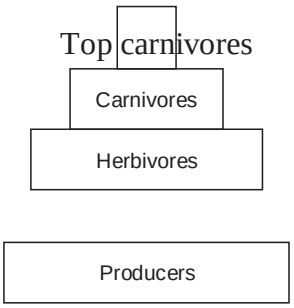


Fig. 3.7. Pyramid of energy.

■ ENERGY FLOW IN AN ECOSYSTEM

Flow of energy in an ecosystem takes place through the food chain and it is this energy flow which keeps the ecosystem going. The most important feature of this energy flow is that it is nnidirectiona1 or one-way f1ow. Unlike the nutrients (like carbon, nitrogen, phosphorus etc.) which move in a cyclic manner and are reused by the producers after flowing through the food chain, energy is not reused in the food chain. Also, the flow of energy follows the two laws of Thermodynamics:

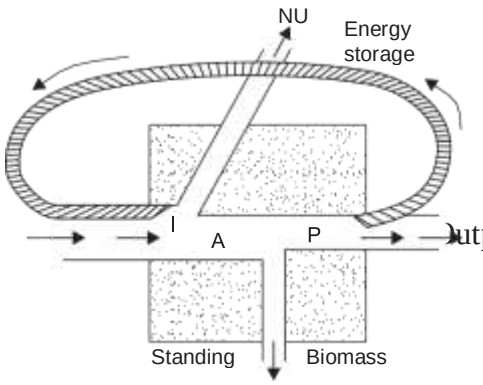
rst 1aw of Thermodynamics states that energy can neither be created nor be destroyed but it can be transformed from one form to another. The solar energy captured by the green plants (producers) gets converted into biochemical energy of plants and later into that of consumers.

rrnd 1aw of Thermodynamics states that energy dissipates as it is used or in other words, its gets converted from a more concentrated to dispersed form. As energy flows through the food chain, there occurs dissipation of energy at every trophic level. The loss of energy takes place through respiration, loss of energy in locomotion, running, hunt- ing and other activities. At every level there is about 90% loss of energy and the energy transferred from one trophic level to the other is only about 10%.

Energy f1ow mode1s: The flow of energy through various trophic levels in an ecosystem can be explained with the help of various energy flow models.

(a) Unirersa1 energy f1ow mode1: Energy flow through an ecosystem was explained by E.P. Odum as the universal energy flow model (Fig. 3.8). As the flow of energy takes place, there is a gradual loss of energy at every level, thereby resulting in less energy available at next trophic level as indicated by narrower pipes (energy flow) and smaller boxes (stored energy in biomass). The loss of energy is mainly the energy not utilized (NU). This is the energy lost in locomotion,

excretion etc. or it is the energy lost in respiration (R) which is for maintenance. The rest of the energy is used for production (P).



Input energy

)utput energy

Respiration

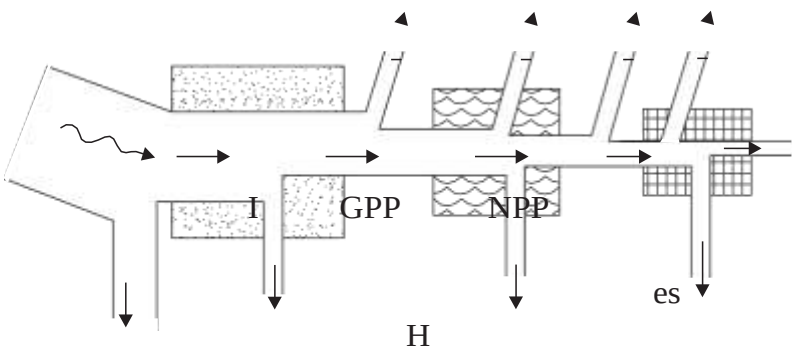
Fig. 3.8. Universal energy flow model applicable to all living components (I = Energy input; A : assimilated energy ; P = Production ; NU = Energy not used.

(&) Sing1e channe1 energy flow mode1: The flow of energy takes place in a unidirectional manner through a single channel of green plants or producers to herbivores and carnivores. Fig. 3.9 depicts such a model and illustrated the gradual decline in energy level due to loss of energy at each successive trophic level in a grazing food chain.

NU

NA NU NA

Sunlight



Producers

H
e
r
b
i
v
o
r

Carnivores

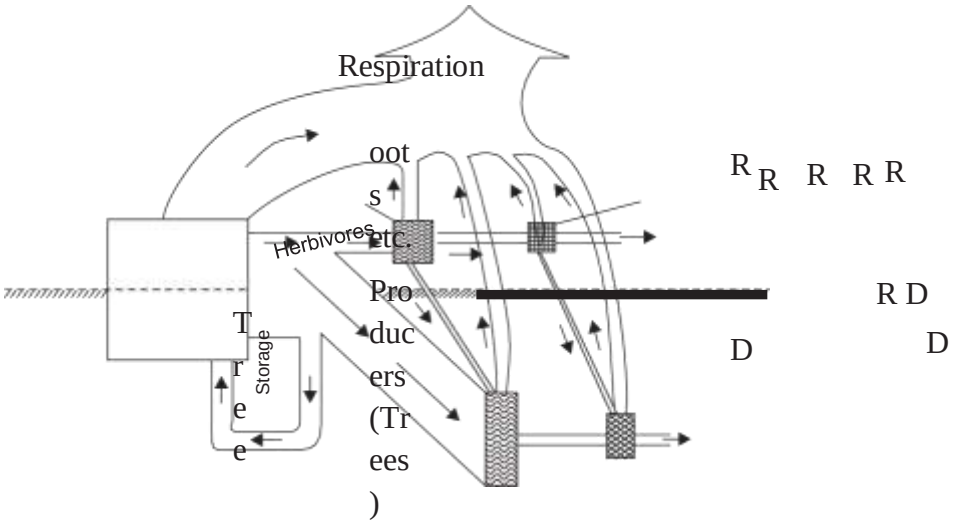
R R R

Heat loss

Fig. 3.9. One-way energy flow model showing unidirectional flow through primary producers, herbivores and carnivores. At each successive trophic level there is huge loss of energy (I = Solar energy input ; GPP = Gross primary production ; NPP = Net primary production ; NU = Energy not used ; NA = Energy not assimilated e.g. excretion ; R = Respiratory loss).

(c) Donble channe1 or Y-shaped energy flow mode1: En nature, both grazing food chain and detritus food chain operate in the same ecosystem. However, sometimes it is the grazing food chain which predominates. Et happens in marine ecosystem where primary production in the open sea is limited and a major portion of it is eaten by herbivorous marine animals. Therefore, very little primary production is left to be passed on to the dead or detritus compartment. On the other hand, in a forest ecosystem the huge quantity of biomass produced cannot be all consumed by herbivores. Rather, a large proportion of the live biomass enters into detritus (dead) compartment in the form of litter. Hence the detritus food chain is more important there.

The two channel or Y-shaped model of energy flow shows the passage of energy through these two chains, which are separated in time and space (Fig 3.10).



Ground level

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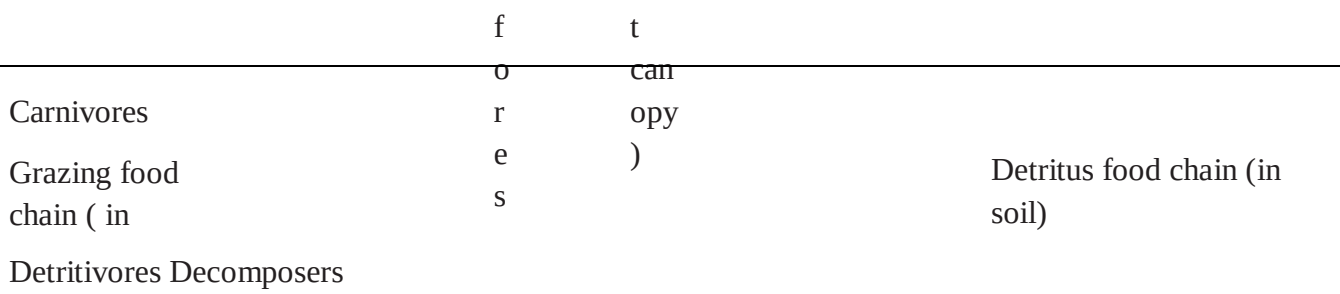


Fig. 3.10. Y-shaped or 2-channel energy flow model showing energy flow through the grazing food chain and the detritus food chain (R = Respiration, D = Detritus or dead matter).

■ NUTRIENT CYCLING

Besides energy flow, the other important functional attribute of an ecosystem is nutrient cycling. Nutrients like carbon, nitrogen, sulphur, oxygen, hydrogen, phosphorus etc. move in circular paths through biotic and abiotic components and are therefore known as biogeochemica1 cyc1es. Water also moves in a cycle, known as hydrological cycle. The nutrients too move through the food chain and ultimately reach the

detritus compartment (containing dead organic matter) where various micro-organisms carry out decomposition. Various organically bound nutrients of dead plants and animals are converted into inorganic substances by microbial decomposition that are readily used up by plants (primary producers) and the cycle starts afresh.

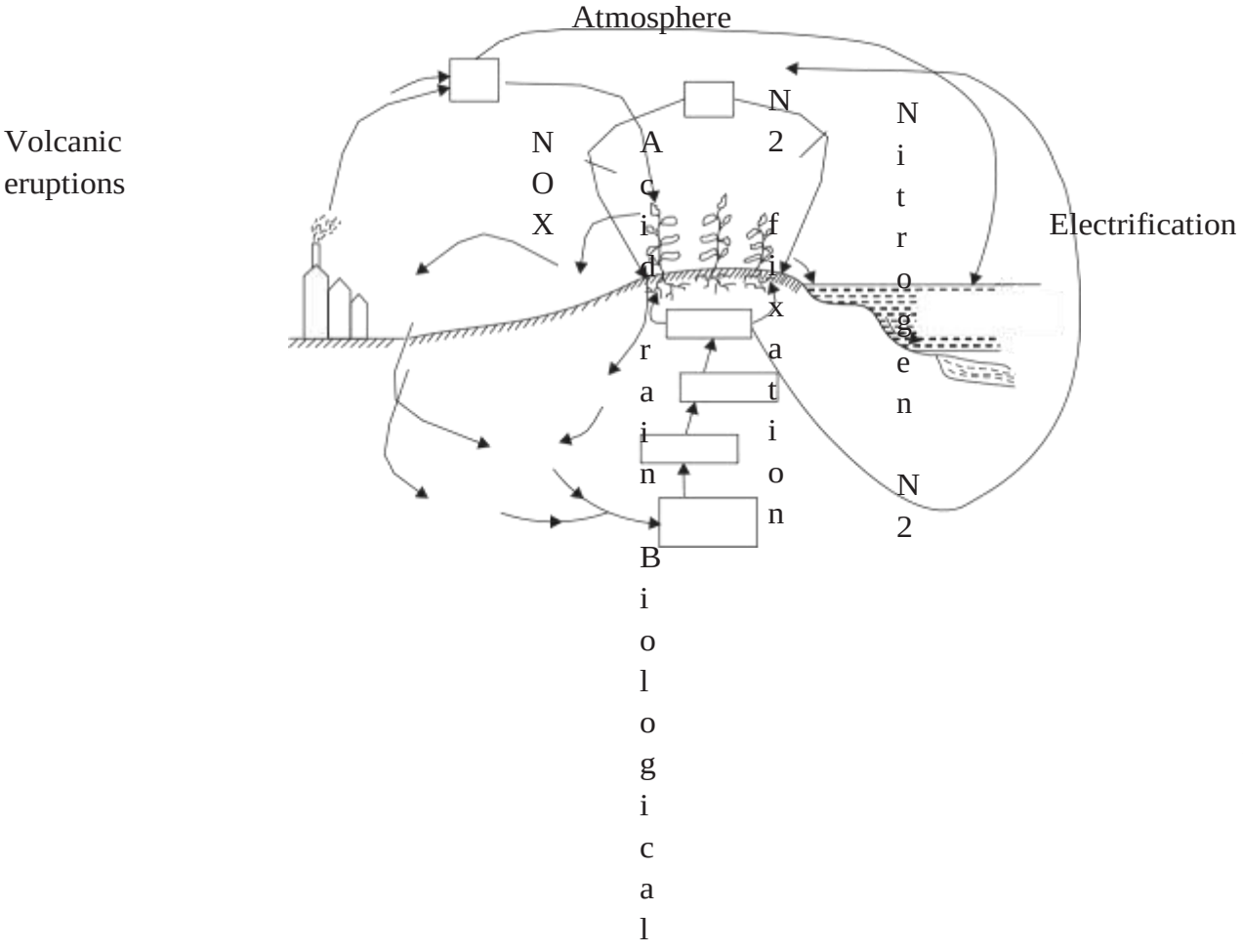
Nitrogen cycle

Cycling of one such important nutrient nitrogen is shown in Fig. 3.11.

Nitrogen is present in the atmosphere as N_2 in large amount (78%) and it is fixed either by the physical process of lightening or biologically by

some bacteria and/or cyanobacteria (blue green algae). The nitrogen is taken up by plants and used in metabolism for biosynthesis of amino acids, proteins, vitamins etc. and passes through the food chain. After death of the plants and animals, the organic nitrogen in dead tissues is decomposed by several groups of ammonifying and nitrifying bacteria which convert them into ammonia, nitrites and nitrates, which are again used by plants. Some bacteria convert nitrates, into molecular nitrogen or N_2 which is released back into the atmosphere and the cycle goes

on.



A cid rain

Fertilizer Runoff (Eutrophication)

Hydro- sphere

Litho-

Animal

Animals

sphere (soil)

Industrial activities

protoplasm

Plant protoplasm

Death

Nitrates

Nitrites

Nitrification

Shallow marine sediments

Loss to deep sediments

and Deacy

Excretion

(Ur

ea, uric acid)

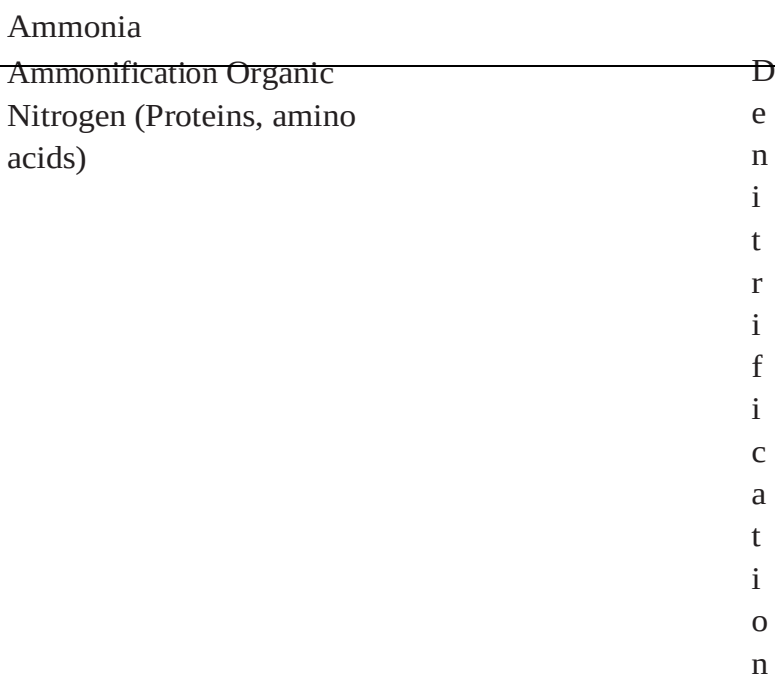


Fig. 3.11. Nitrogen cycle—a gaseous cycle with major reserve as N_2 (78%) in the atmosphere. Circulation of N- between living components and soil/atmosphere is mediated by a group of micro-organisms which convert one form of N into another.

Carbon Cycle

Sometimes human interferences disturb the normal cycling of such nutrients and create imbalances. For example, nature has a very bal- anced carbon cycle (Fig. 3.12). Carbon, in the form of carbon dioxide is taken up by green plants as a raw material for photosynthesis, through which a variety of carbohydrates and other organic substances are pro- duced. Through the food chain it moves and ultimately organic carbon present in the dead matter is returned to the atmosphere as carbon dioxide by microorganisms. Respiration by all organisms produces carbon dioxide, while the latter is used up by plants.

En the recent years carbon dioxide levels have increased in the atmosphere due to burning of fossil fuels etc. which has caused an imbalance in the natural cycle and the world today is facing the serious problem of global warming due to enhanced carbon dioxide emissions.

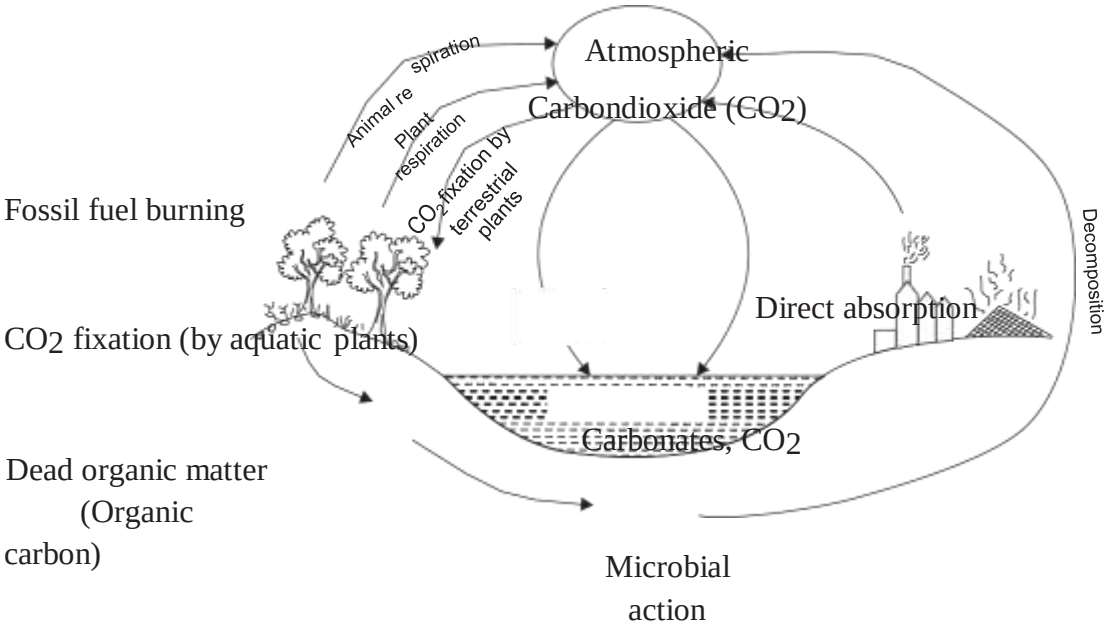


Fig. 3.12. Carbon cycle.

Phosphorus cycle

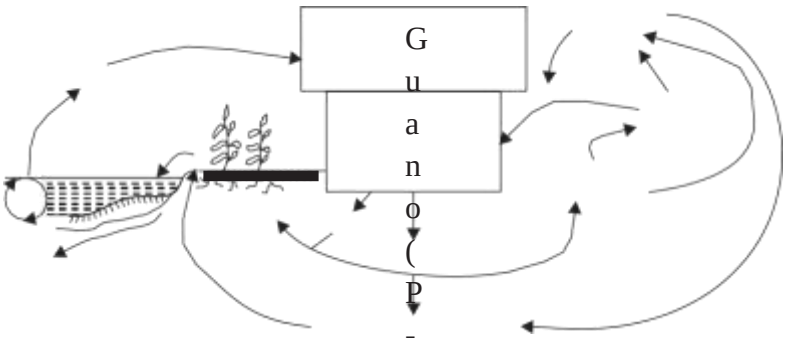
Phosphorous cycle is another important nutrient cycle-which is shown in Fig. 3.13. The reservoir of phosphorus lies in the rocks, fossils etc. which is excavated by man for using it as a fertilizer. Farmers use the phosphate fertilizers indiscriminately and as a result excess phosphates are lost as run-off, which causes the problem of eutrophication or overnourishment of lakes leading to algal blooms as already discussed

Death and decay

Sea birds

Excreta

Preserves Guano (P-rich) deposits



ion

Marine fish etc.

Eutro-

Runoff

phicat

Fertilizers (PO_4)

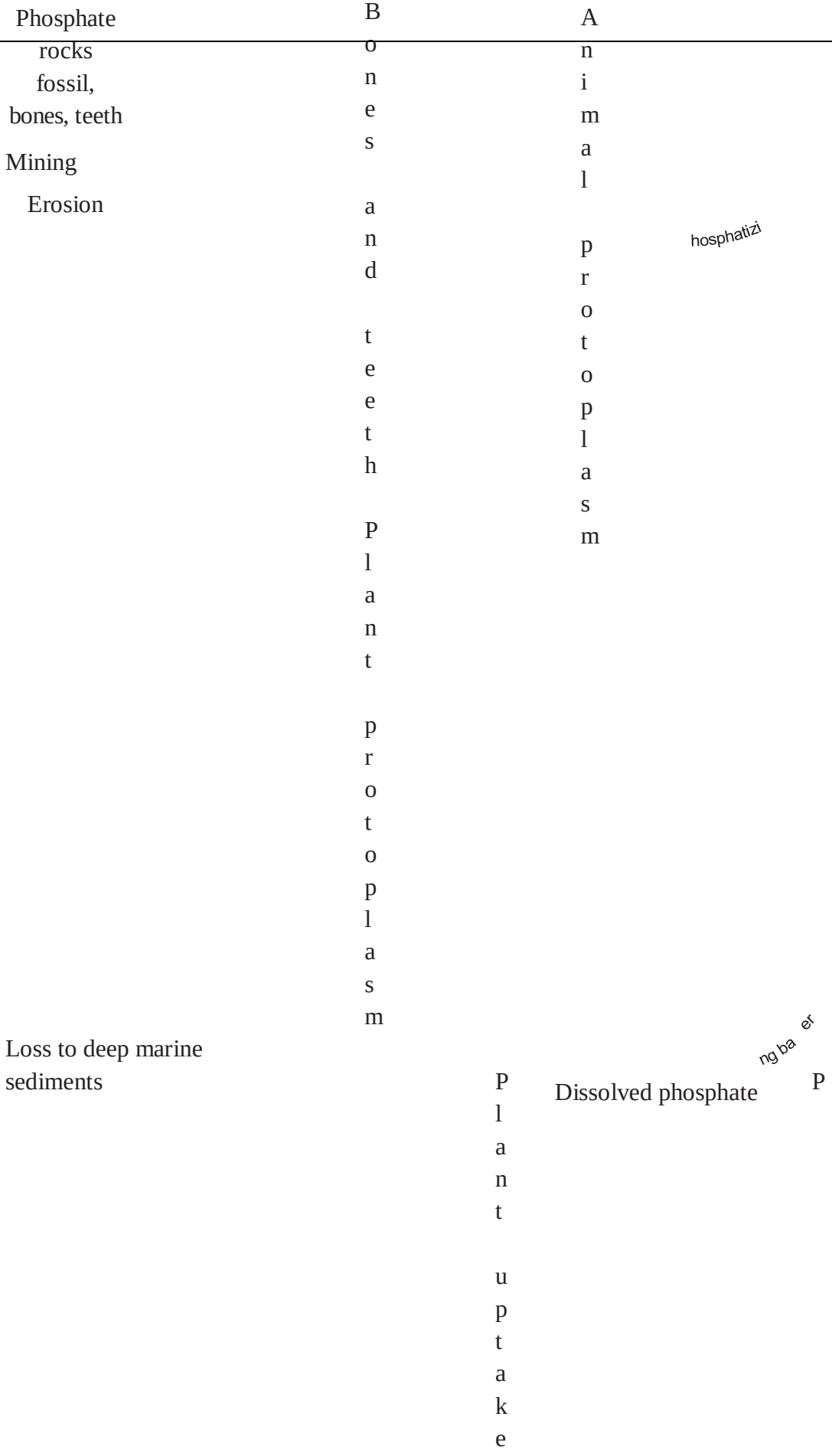


Fig. 3.13. Phosphorus cycle—a sedimentary cycle with major reserves of phosphorus in the sediments.

in unit 2. A good proportion of phosphates moving with surface run- off reaches the oceans and are lost into the deep sediments. Our limited supply of phosphorus lying in the phosphate rocks of this earth are

thus over-exploited by man and a large part is taken out of the normal cycle due to loss into oceans. So human beings are making the phosphorous cycle acyclic. Sea birds, on the other hand, are playing an important role in phosphorus cycling. They eat sea-fishes which are phosphorus rich and the droppings or excreta of the birds return the phosphorus on the land. The Guano deposits on the coasts of Peru are very rich sources of phosphorus.

■ PRIMARY PRODUCTION

Primary prodnctirity of an ecosystem is defined as the rate at which radiant energy is conrerted into organic snbstances by photosyn- thesis or chemo-synthesis by the primary prodncers.

When organic matter is produced by the primary producers (mainly green plants and some microorganisms), some of it is oxidized or burnt inside their body and converted into carbon-dioxide which is released during respiration and is accompanied by loss of energy. Respiratory loss of energy is a must, because it is required for the maintenance of the organism. Now, the producers are left with a little less organic matter than what was actually produced by them. This is known as the net primary prodnction (NPP) and the respiratory loss
(R) added to it gives the gross primary prodnction (GPP). Thus, NPP = GPP – R.

Primary production of an ecosystem depends upon the solar radiations, availability of water and nutrients and upon the type of the plants and their chlorophyll content. Table 3.1 shows the average gross primary productivity of some majorecosystems.

Tab1e 3.1. Annna1 arerage of gross primary prodnction of some major ecosystems

Ecosyste m	Gross Primary Prodncti rity (K Ca1/m^2 /yr)
Deserts and Tundra	200
Open Oceans	1,000
Grassland s	2,700
Moist Temperat e Forests	8,000
Agro- ecosyste ms	12,000
Wet Tropical Forests	20,000
Estuaries	20,000

Productivity of tropical forests and estuaries are the highest. This is because tropical forests have abundant rainfall, warm temperature congenial for growth, abundant sunlight and a rich diversity of species. Estuaries get natural energy subsidies in the form of wave currents that bring along with them nutrients required for production.

Deserts on the other hand, have limitations of adequate water supply while Tundra have very low temperature as limiting factor and hence show low primary production.

Agro-ecosystems get lots of energy subsidies in the form of irrigation water, good quality seeds, fertilizers and pesticides and show a high productivity of 12,000 K Cal/m^2/yr. Still, it is noteworthy that their productivity is less than that of tropical forests which are not receiving any artificial energy subsidies. Nature itself has designed its species composition, structure, energy capture and flow, and a closed nutrient cycling system that ensures a high primary production of 20,000 K Cal/m^2/yr. Also, the

qualitative variety of the primary production is enormous in the tropical forests. This makes it all the more important to conserve our tropical forests.

Secondary Production

The food synthesized by green plants through photosynthesis is the primary production which is eaten by herbivores. The plant energy is used up for producing organic matter of the herbivores which, in turn, is used up by the carnivores. The amount of organic matter stored by the herbivores or carnivores (in excess of respiratory loss) is known as secondary production. The energy stored at consnmer 1er1 for nse by the next trophic 1er1 is thns defined as secondary prodnction.

■ ECOSYSTEM REGULATION

All ecosystems regulate themselves and maintain themselves under a set of environmental conditions. Any environmental stress tries to disturb the normal ecosystem functions. However, the ecosystem, by itself, tries to resist the change and maintain itself in equilibrium with the environment due to a property known as homeostasis. Homeostasis is the inherent property of a11 1iring systems to resist change. However, the system can show this tolerance or resistance only within a maximum and a minimum range, which is its range of tolerance known as homeos5a5¿c pla5eau. Within this range, if any stress tries to cause a deviation, then the system has its own mechanisms to counteract these deviations which are known as negatire feedback mechanisms. So negatire feedback mechanisms are deriation connteracting mechanisms which try to bring the system back to its idea1 conditions. But, if the stress is too high and beyond the range of homeostatic plateau, then another type of mechanisms known as positire feedback mechanisms start operating. These are the deviation accelerating mechanisms. So the positire feedback mechanisms add to the stress conditions and tend to take the system away from the optima1 conditions. Fig. 3.14 depicts the ecosystem regulation mechanisms.

Human beings should try to keep the ecosystems within the homeostatic plateau. They should not contribute to positive feedbacks otherwise the ecosystems will collapse.

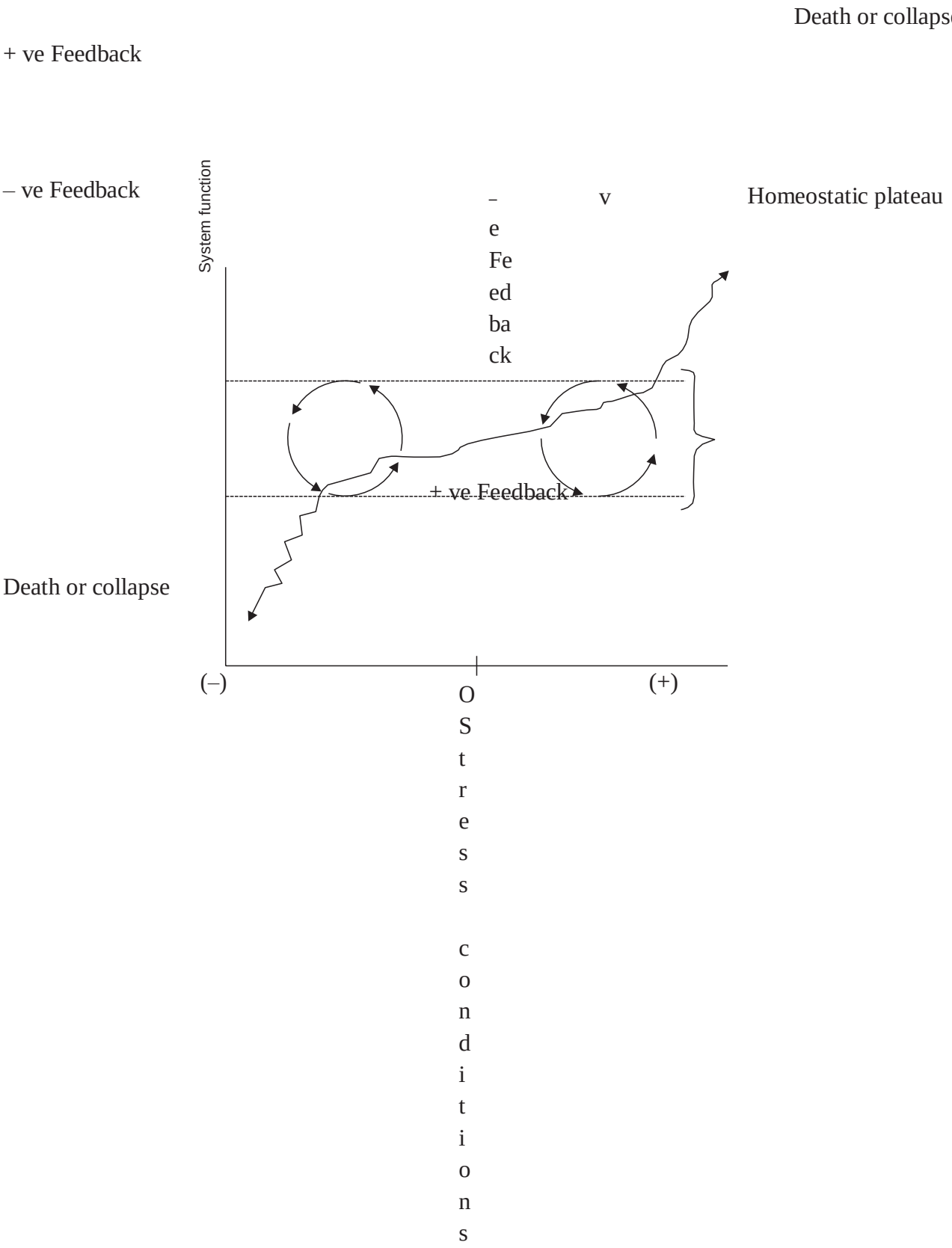


Fig. 3.14. Ecosystem regulation by homeostasis. On application of a stress, the negative feedback mechanisms start operating, trying to counter the stress to regulate the system. But beyond the

homeostatic plateau, positive feedback starts which further accelerate the stress effects causing death or collapse of the organism/system.

■ ECOLOGICAL SUCCESSION

An ecosystem is not static in nature. Et is dynamic and changes its structure as well as function with time and quite interestingly, these changes are very orderly and can be predicted. Et is observed that one type of a community is totally replaced by another type of community over a period of time and simultaneously several changes also occur. This process is known as ecological succession.

Eco1ogica1 snccession is defined as an order1y process of changes in the commnnity strnctnre and fnnction with time mediated throngh modifications in the physica1 enrironment and n1timate1y cn1minating in a stabi1ized ecosystem known as c1imax. The whole sequence of communities which are transitory are known as Seral s5ages or seres whereas the community establishing first of all in the area is called a p¿oneer community.

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

(¿) Hydrarch or Hydrosere: Starting in watery area like pond, swamp, bog

(¿¿) Mesarch: starting in an area of adequate moisture.

(¿¿¿) Xerarch or Xerosere: Starting in a dry area with little moisture. They can be of the following types:

Lithosere : starting on a bare rock Psammosere : starting on sand Halosere : starting on saline soil

Process of Succession

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

(¿) Nndation: Et is the development of a bare area without any life form. The bare area may be caused due to landslides, volcanic eruption etc. (topographic factor), or due to drought, glaciers, frost etc. (Climatic factor), or due to overgrazing, disease outbreak, agricultural/ industrial activities (biotic factors).

(¿¿) rnrasion: Et is the successful establishment of one or more species on a bare area through dispersa1 or migration, followed by ecesis or estab1ishment. Dispersal of the seeds, spores etc. is brought about by wind, water, insects or birds. Then the seeds germinate and grow on the land. As growth and reproduction start, these pioneer species increase in number and form groups or aggregations.

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

(¿v) Reaction: The living organisms grow, use water and nutrients from the substratum, and in turn, they have a strong influence on the environment which is modified to a large extent and this is known as reaction. The modifications are very often such that they become unsuitable for the existing species and favour some new species, which replace them. Thus, reaction leads to several sera1 commnnities.

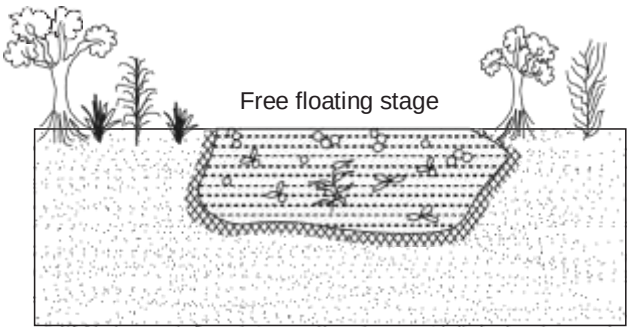
(v) Stabi1ization: The succession ultimately culminates in a more or less stable community called c1imax which is in equilibrium with the environment.

The climax community is characterized by maximum biomass and symbiotic (mutually beneficial) linkages between organisms and are maintained quite efficiently per unit of available energy.

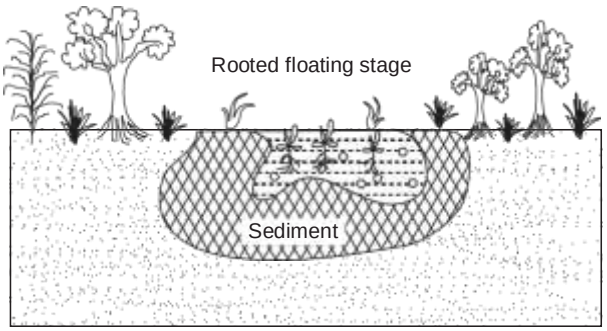
Let us consider very briefly two types of succession.

A. Hydrosere (Hydrarch): This type of succession starts in a water body like pond. A number of intermediate stages come and ultimately it culminates in a climax community which is a forest.

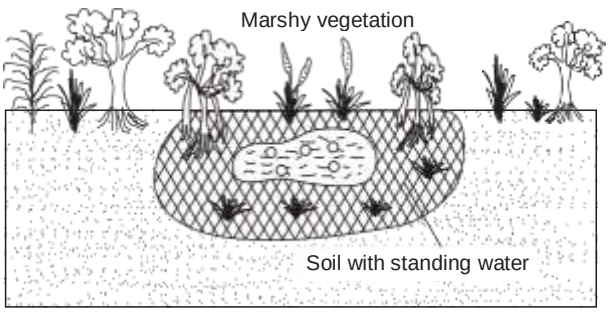
The pioneer community consists of phytoplanktons, which are free floating algae, diatoms etc. Gradually these are replaced by rooted- submerged plants followed by rooted-floating plants. Growth of these plants keep on adding organic matter to the substratum by death and



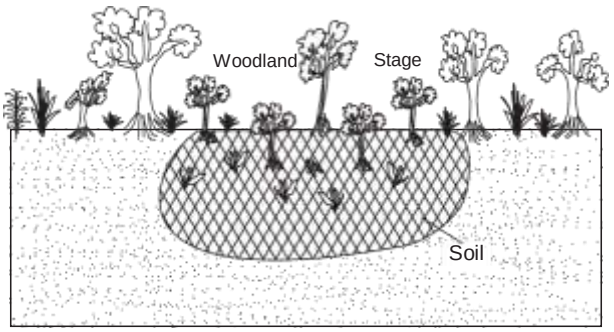
(a) Open water body (lake), sediment brought in by river.



(b) Sediment accumulation continues, organic debris from plants too add to soil formation and shrinking of water body occurs.



(c) A mat of vegetation covers the water which is mostly a marshy habitat now, with a small part as aquatic system.



(d) Eventually the former lake is covered by climax woodland community, representating a terrestrial ecosystem.

Fig. 3.15. Ecological succession: A hydrach—from lake to woodland community.

decay and thus a layer of soil builds up and shallowing of water takes place. Then Reed swamp (marshy) stage follows in which the plants are partly in water and partly on land. This is followed by a sedge-meadow stage of grasses then by a woodland consisting of shrubs and trees and finally by a forest acting as climax. (Fig. 3.17)

B. Xerosere (Xerarch): This type of succession originates on a bare rock, which lacks water and organic matter. Enterestingly, here also the climax community is a forest, although the intermediate stages are very different.

The pioneer community here consists of crustose and foliose lichens. These lichens produce some weak acids and help in disintegrating the rock, a process known as wea5her¿ng. Their growth helps in building up gradually some organic matter, humus and soil. Then comes the community of mosses, followed by herbs, shrubs and finally the forest trees. Throughout this gradual process there is a slow build up of organic matter and water in the substratum.

Thus, succession tends to move towards mesic conditions (moderate condition), irrespective of the fact, whether it started from a dry (Xeric) condition or a moist (hydric) condition and it culminates in a stable climax community, which is usually a forest.

MAJOR ECOSYSTEM TYPES

Let us consider types, characteristic features, structure and functions of some major ecosystems.

■ FOREST ECOSYSTEM

These are the ecosystems having a predominance of trees that are interspersed with a large number of species of herbs, shrubs, climbers, lichens, algae and a wide variety of wild animals and birds. As discussed above forests are found in undisturbed areas receiving moderate to high rainfall and usually occur as stable climax communities.

Depending upon the prevailing climatic conditions forests can be of various types:

(a) Tropica1 Rain Forests: They are evergreen broadleaf forests found near the equator. They are characterized by high temperature, high humidity and high rainfall, all of which favour the growth of trees. All through the year the climate remains more or less uniform. They are the richest in biodiversity. Different forms of life occupy specialized areas (niches) within different layers and spaces of the ecosystem depending upon their needs for food, sunlight, water, nutrient etc.

We come across different types and layers of plants and animals in the tropical rain forests. e.g. the emergent 1ayer is the topmost layer of the tallest broad-leaf evergreen trees, below which lies the canopy where top branches of shorter trees form an umbrella like cover. Below this is present the nnderstory of still smaller trees. On the tree trunks some woody climbers are found to grow which are known as Lianas. There are some other plants like Orchids which are epiphytes i.e. they are attached to the trunks or branches of big trees and they take up water and nutrients falling from above. The orchids have special type of leaves to capture and hold the water. Some large ep¿phy5es can hold as much as # l¿5res o/ wa5er, egu¿valen5 5o a small &uc#e5! Thus, these epiphytes almost act like mini-ponds suspended up in the air, in the forest crown. That is the reason why a large variety of birds, insects and animals like monkeys have made their natural homes (habitats) in these forests (Plate EE).

The understorey trees usually receive very dim sunlight. They usually develop dark green leaves with high chlorophyll content so that they can use the diffused sunlight for photosynthesis. The shrnb 1ayer receives even less sunlight and the gronnd 1ayer commonly known as forest f1oor receives almost no sunlight and is a dark layer. Most of the animals like bats, birds, insects etc. occupy the bright canopy layer while monkeys, toads, snakes, chameleons etc. keep on moving up and down in sunny and darker layers. Termites, fungi, mushrooms etc. grow on the ground layer. Warm temperature and high availability of moisture facilitate rapid breakdown (decomposition) of the dropped leaves, twigs etc. releasing the nutrients rapidly. These nutrients are immediately taken up by the mycorrhiza1 roots of the trees.

Plate II. Tropical rain forest.

Enterestingly, the flowers of forest trees are very large, colourful, fragrant and attractive which helps in pollination by insects, birds, bats etc. Aa//les¿a arnold¿, the biggest flower (7 kg weight) is known to smell like rotten meat and attracts flies and beetles which help in its pollination (Plate EEE).

Plate III. Rafflesia—the biggest flower.

The Silent Valley in Kerala is the only tropical rain forest lying in Endia which is the natural habitat for a wide variety of species.

Being the store-house of biodiversity, the forests provide us with an array of commercial goods like timber, fuel wood, drugs, resins, gums etc. Unfortunately there is cutting down of these forests at an alarming rate. Within the next 30-40 years we are likely to be left with only scattered fragments of such forests, thereby losing the rich biodiversity and the ecological uses of forests, discussed earlier in unit EE.

(&) Tropica1 decidnons forests: They are found a little away from the equator and are characterized by a warm climate the year round. Rain occurs only during monsoon. A large part of the year remains dry and therefore different types of deciduous trees are found here, which lose their leaves during dry season.

(c) Tropica1 scrnb forests: They are found in areas where the dry season is even longer. Here there are small deciduous trees and shrubs.

(d) Temperate rain forests: They are found in temperate areas with adequate rainfall. These are dominated by coniferous trees like pines, firs, redwoods etc. They also consist of some evergreen broad- leaf trees.

(e) Temperate decidnons forests: They are found in areas with moderate temperatures. There is a marked seasonality with long sum- mers, cold but not too severe winter and abundant rainfall throughout the year. The major trees include broad leaf deciduous trees like oak, hickory, poplar etc.

(/) Errergreen coniferons forests (Borea1 Forests): They are found just south of arctic tundra. Here winters are long, cold and dry. Sunlight is available for a few hours only. En summer the temperature is mild, sun-shines for long hours but the season is quite short. The major trees include pines, spruce, fir, cedar etc. which have tiny, nee- dle-shaped leaves having a waxy coating so that they can withstand severe cold and drought. The soil is found to get frozen during winter when few species can survive. The leaves, also know as needles, fall on the forest floor and cover the nutrient poor soil. These soils are acidic and prevent other plants from growing. Species diversity is rather low in these forests.

■ GRASSLAND ECOSYSTEMS

Grasslands are dominated by grass species but sometimes also allow the growth of a few trees and shrubs. Rainfall is average but erratic. Limited grazing helps to improve the net primary production of the grasslands but overgrazing leads to degradation of these grasslands resulting in desertification. Three types of grasslands are found to occur in different climatic regions:

(a) Tropica1 grass1ands: They occur near the borders of tropical rain forests in regions of high average temperature and low to moderate rainfall. En Africa, these are typically known as Sarannas, which have tall grasses with scattered shrubs and stunted trees. The Savannas have a wide diversity of animals including zebras, giraffes, gazelle, antelopes etc. During dry season, fires are quite common. Termite mounds are very common here. The termites gather the detritus (dead organic matter) containing a lot of cellulose and build up a mound. On the top of the mound fungi are found to grow which feed upon this dead matter including cellulose and in turn release methane, a greenhouse gas.

Tropical savannas have a highly efficient system of photosynthesis. Most of the carbon assimilated by them in the form of carbohydrates is in the perennating bulbs, rhizomes, runners etc. which are present underground. Deliberate burning of these grasslands can relase huge quantities of carbon dioxide, another green house gas, responsible for global warming.

(&) Temperate grass1ands: They are usually found on flat, gentle sloped hills, winters are very cold but summers are hot and dry. Entense grazing and summer fires do not allow shrubs or trees to grow.

En United States and Canada these grasslands are known as prairies, in South America as Pampas, in Africa as Ve1ds and in central Europe and Asia they are known as Steppes.

Winds keep blowing and evaporation rate is very high. Et also favours rapid fires in summer. The soils are quite fertile and therefore, very often these grasslands are cleared for agriculture.

(c) Po1ar grass1ands (Arctic Tnndra): They are found in arctic polar region where severe cold and strong, frigid winds along with ice and snow create too harsh a climate for trees to grow. En summers the sun-shines almost round the clock and hence several small annual plants grow in the summer. The animals include arctic wolf, weasel, arctic fox, reindeer etc. A thick layer of ice remains frozen under the soil surface throughout the year and is known as permafrost. En summer, the tundra shows the appearance of shallow lakes, bogs etc. where mosquitoes, different type of insects and migratory birds appear.

■ DESERT ECOSYSTEMS

These ecosystems occur in regions where evaporation exceeds precipitation (rainfall, snow etc.). The precipitation is less than 27 cm per year. About 1/3rd of our world³s land area is covered by deserts. Deserts have little species diversity and consist of drought resistant or drought avoiding plants. The atmosphere is very dry and hence it is a poor insulator. That is why in deserts the soil gets cooled up quickly, making the nights cool. Deserts are of three major types, based on climatic conditions:

(a) Tropica1 deserts like Sahara and Namib in Africa and Thar desert, Rajasthan, Endia are the driest of all with only a few species. Wind blown sand dunes are very common.

(&) Temperate deserts like Mojave in Southern California where day time temperatures are very hot in summer but cool in winters.

(c) Co1d deserts like the Gobi desert in China has cold winters and warm summers.

Desert plants and animals are having most typical adaptations for conservation of water. Many desert plants are found to have re- duced, scaly leaves so as to cut down loss of water due to transpiration or have succulent leaves to store water. Many a times their stems get flattened and develop chlorophyll so that they can take up the function of photosynthesis. Some plants show very deep roots to tap the groundwater. Many plants have a waxy, thick cuticle over the leaf to reduce loss of water through transpiration. Desert animals like insects and reptiles have thick outer coverings to minimize loss of water. They usually live inside burrows where humidity is better and heat is less. Desert soil is rich in nutrients but deficient in water.

Due to low species diversity, shortage of water and slow growth rate, the desert plant communities, if faced with a severe stress take a long time to recover.

■ AQUATIC ECOSYSTEMS

Aquatic ecosystems dealing with water bodies and the biotic communities present in them are either freshwater or marine. Freshwater ecosystems are further of standing type (1entic) like ponds and lakes or free-flowing type (1otic), like rivers. Let us consider some important aquatic ecosystems.

(a) Pond ecosystem: Et is a small freshwater aquatic ecosystem where water is stagnant. Ponds may be seasonal in nature i.e. receiving

enough water during rainy season. Ponds are usually shallow water bodies which play a very important role in the villages where most of the activities center around ponds. They contain several types of algae, aquatic plants, insects, fishes and birds. The ponds are, however, very often exposed to tremendous anthropogenic (human-generated) pres- sures. They are used for washing clothes, bathing, swimming, cattle bathing and drinking etc. and therefore get polluted.

(&) Lake ecosystems: Lakes are usually big freshwater bodies with standing water. They have a shallow water zone called Littora1 zone, an open-water zone where effective penetration of solar light takes place, called Limnetic zone and a deep bottom area where light penetration is negligible, known as profnnda1 zone (Fig. 3.16).

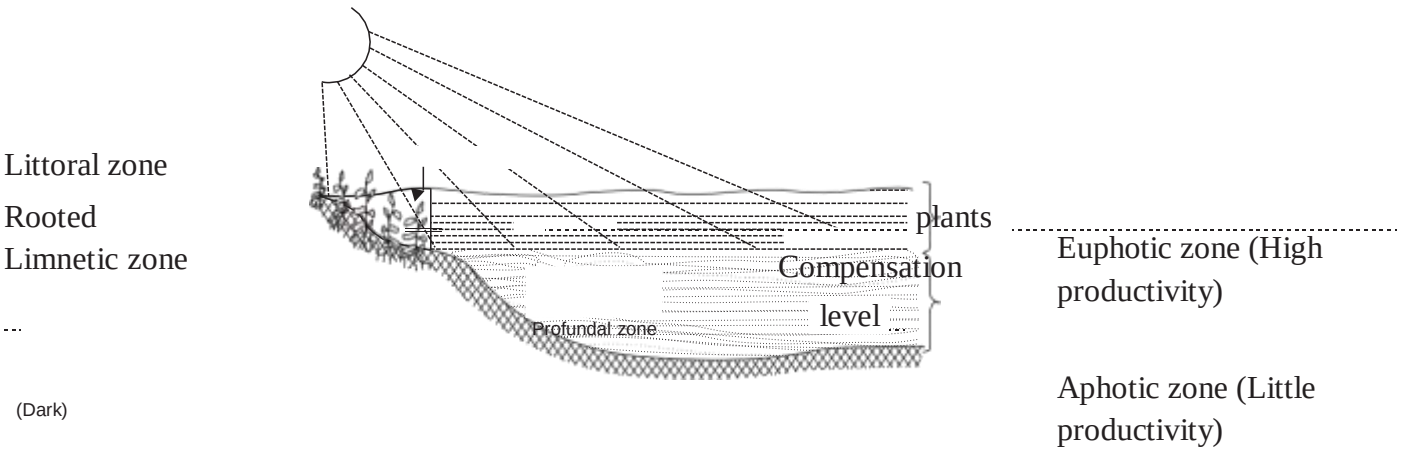


Fig. 3.16. Zonation in a lake ecosystem.

The Dal Lake in Srinagar (J & K), Naini Lake in Nainital (Uttaranchal) and Loktak lake in Manipur are some of the famous lakes of our country.

Organisms : The lakes have several types of organisms:

(a) P1anktons that float on the surface of waters e.g. phy5oplan#5ons like algae and xooplan#5ons like rotifers. (&) Nektons that swim e.g. fishes.

(c) Nenstons that rest or swim on the surface.

(d) Benthos that are attached to bottom sediments e.g. snails.

(e) Periphytons that are attached or clinging to other plants or any other surface e.g. crustaceans.

Stratification : The lakes show stratification or zonation based on temperature differences. During summer, the top waters become warmer than the bottom waters. Therefore, only the warm top layer

circulates without mixing with the colder layer, thus forming a distinct zonation:

Epi1imnion : Warm, lighter, circulating surface layer

Hypo1imnion : Cold, viscous, non-circulating bottom layer.

Enbetweenthetwolayersisthermoc1ine,theregionofsharpdrop in temperature.

Types of Lakes : Some important types of lakes are:

(a) O1igotrophic 1akes which have low nutrient concentrations. (&) Entrophic 1akes which are overnourished by nutrients like nitrogen and phosphorus, usually as a result of agricultural run-off or municipal sewage discharge. They are covered with "algal blooms" e.g. Dal Lake.

(c) Dystrophic 1akes that have low pH, high humic acid content and brown waters e.g. bog lakes.

(d) Endemic 1akes that are very ancient, deep and have endemic fauna which are restricted only to that lake e.g. the Lake Baikal in Russia; the deepest lake, which is now suffering a threat due to industrial pollution.

(e) Desert sa1t 1akes that occur in arid regions and have devel- oped high salt concentrations as a result of high evaporation.

e.g. great salt lake, Utah; Sambhar lake in Rajasthan.

(/) Vo1canic 1akes that receive water from magma after volcanic eruptions e.g. many lakes in Japan. They have highly restricted biota.

(g) Meromictic 1akes that are rich in salts and are permanently stratified e.g. lake Nevada.

(h) Artificia1 1akes or imponndments that are created due to con- struction of dams e.g. Govindsagar lake at Bhakra-Nangal.

Streams

These are freshwater aquatic ecosystems where water current is a major controlling factor, oxygen and nutrient in the water is more uniform and land-water exchange is more extensive. Although stream organisms have to face more extremes of temperature and action of currents as compared to pond or lake organisms, but they do not have to face oxygen deficiency under natural conditions. This is because the streams are shallow, have a large surface exposed to air and constant motion which churns the water and provides abundant oxygen. Their dissolved oxygen level is higher than that of ponds even though the green plants

are much less in number. The stream animals usually have a narrow range of tolerance to oxygen. That is the reason why they are very susceptible to any organic pollution which depletes dissolved oxygen in the water. Thus, streams are the worst victims of industrial development.

Rirer Ecosystem: Rivers are large streams that flow downward from mountain highlands and flowing through the plains fall into the sea. So the river ecosystems show a series of different conditions.

The monntain high1and part has cold, clear waters rushing down as water falls with large amounts of dissolved oxygen. The plants are attached to rocks (periphytons) and fishes are cold-water, high oxygen requiring fish like trouts.

rn the second phase on the gentle slopes, the waters are warmer and support a luxuriant growth of plants and less oxygen requiring fishes.

rn the third phase, the river waters are very rich in biotic diversity. Moving down the hills, rivers shape the land. They bring with them lots of silt rich in nutrients which is deposited in the plains and in the delta before reaching the ocean.

Oceans

These are gigantic reservoirs of water covering more than 70% of our earth³s surface and play a key role in the survival of about 2,70,000 marine species, serving as food for humans and other organisms, give a huge variety of sea-products and drugs. Oceans provide us iron, phosphorus, magnesium, oil, natural gas, sand and gravel.

Oceans are the major sinks of carbon dioxide and play an important role in regulating many biogeochemical cycles and hydrological cycle, thereby regulating the earth³s climate.

The oceans have two major life zones: (Fig. 3.17)

Coasta1 zone with relatively warm, nutrient rich shallow water. Due to high nutrients and ample sunlight this is the zone of high primary productivity.

Open sea: Et is the deeper part of the ocean, away from the continental shelf (The submerged part of the continent). Et is vertically divided into three regions:

(¿) Enphotic zone which receives abundant light and shows high photosynthetic activity.

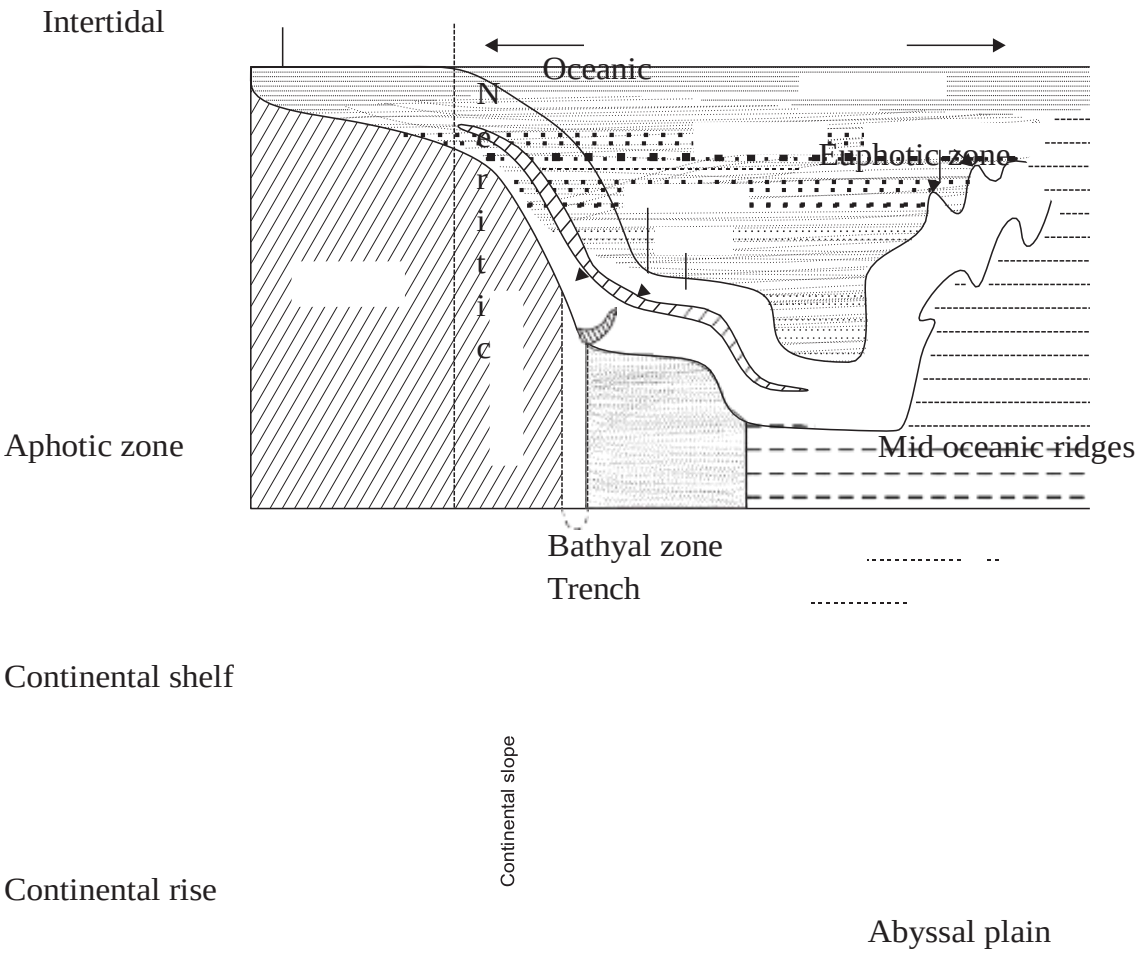


Fig. 3.17. Vertical and horizontal zonation of a marine ecosystem.

(¿¿) Bathya1 zone receives dim light and is usually geologically active.

(¿¿¿) Abyssa1 zone is the dark zone, 2000 to 7000 metres deep. The abyssal zone has no primary source of energy i.e. solar energy. Et is the world³s largest ecological unit but it is an incomplete ecosystem.

Estuary

An estuary is a partially enclosed coastal area at the mouth of a river where fresh water and salty seawater meet. These are the transition zones which are strongly affected by tidal action. Constant mixing of water stirs up the silt which makes the nutrients available for the pri- mary producers. There are wide variations in the stream flow and tidal currents at any given location diurnally, monthly and seasonally. There- fore, the organisms present in estuaries show a wide range of tolerance to temperature and salinity. Such organisms are known as enrytherma1 and enryha1ine. Coastal bays, and tidal marshes are examples of estu- aries.

Estuaries have a rich biodiversity and many of the species are en- demic. There are many migratory species of fishes like eels and salmons in which half of the life is spent in fresh water and half in salty water. For them estuaries are ideal places for resting during migration, where they also get abundant food. Estuaries are

highly productive ecosys- tems. The river flow and tidal action provide energy subsidies for the estuary thereby enhancing its productivity. Estuaries are of much use

UNIT

Biodiversity 3 and its Conservation

Ef we divide the whole earth³s mass into 10 billion parts, it is only in one part where life exists and the astounding variety of living organ- isms numbering somewhere around 70 million species are all restricted to just about a kilometer- thick layer of soil, water and air. Esn³t it won- derful to see that so much diversity has been created by nature on this earth from so little physical matter!

Biodirersity refers to the rariety and rariabi1ity among a11 gronps of 1iring organisms and the ecosystem comp1exes in which they occnr. From the driest deserts to the dense tropical rainforests and from the high snow-clad mountain peaks to the deepest of ocean trenches, life occurs in a marvellous spectrum of forms, size, colour and shape, each with unique ecological inter-relationships. Just imag- ine how monotonous and dull the world would have been had there been only a few species of living organisms that could be counted on fingertips!

rn the Conrention of Bio1ogica1 direrSity (1992) biodirersity has been defined as the rariabi1ity among 1iring organisms from a11 sonrces inc1nding inter alia, terrestria1, marine and other aqnatic ecosystems and the eco1ogica1 comp1exes of which they are a part.

Levels of Biodiversity

Units of biodiversity may range from the genetic level within a species to the biota in a specific region and may extend up to the great diver- sity found in different biomes.

■ GENETIC DIVERSITY

Et is the basic source of biodiversity. The genes found in organisms can form enormous number of combinations each of which gives rise to some variability. Genes are the basic units of hereditary information transmitted from one generation to other. When the genes within the same species show different versions due to new combinations, it is called genetic variability. For example, all rice varieties belong to the

species Oryxa sa5¿va, but there are thousands of wild and cultivated va- rieties of rice which show variations at the genetic level and differ in their color, size, shape, aroma and nutrient content of the grain. This is the genetic diversity of rice.

■ SPECIES DIVERSITY

This is the variability found within the population of a species or between different species of a community. Et represents broadly the species richness and their abundance in a community. There are two popular indices of measuring species diversity known as Shannon~W¿ener
¿ndex and S¿mpson ¿ndex.

What is the number of species on this biosphere? The estimates of actual number vary widely due to incomplete and indirect data. The current estimates given by Wilson in 1992 put the total number of living species in a range of 10 million to 70 million. Till now only about
1.7 million living and 300,000 fossil species have been actually described and given scientific names. Et is quite likely that a large fraction of these species may become extinct even before they are discovered and enlisted.

■ ECOSYSTEM DIVERSITY

This is the diversity of ecological complexity showing variations in ecological niches, trophic structure, food-webs, nutrient cycling etc. The ecosystems also show variations with respect to physical parameters like moisture, temperature, altitude, precipitation etc. Thus, there occurs tremendous diversity within the ecosystems, along these gradients. We may consider diversity in forest ecosystem, which is supposed to have mainly a dominance of trees. But, while considering a tropical rainforest, a tropical deciduous forest, a temperate deciduous forest and a boreal forest, the variations observed are just too many and they are mainly due to variations in the above mentioned physical factors. The ecosystem diversity is of great value that must be kept intact. This diversity has developed over millions of years of evolution. Ef we destroy this diversity, it would disrupt the ecological balance. We cannot even replace the diversity of one ecosystem by that of another. Coniferous trees of boreal forests cannot take up the function of the trees of tropical deciduous forest lands and vice versa, because ecosystem diversity has evolved with respect to the prevailing environmental conditions with well- regulated ecological balance.

■ BIOGEOGRAPHICAL CLASSIFICATION OF INDIA

Endia has different types of climate and topography in different parts of the country and these variations have induced enormous variability in flora and fauna. Endia has a rich heritage of biological diversity and occupies the tenth position among the plant rich nations of the world.

Et is very important to study the distribution, evolution, dispersal and environmental relationship of plants and animals in time and space. Biogeography comprising of phytogeography and zoogeography deals with these aspects of plants and animals. En order to gain insight about the distribution and environmental interactions of flora and fauna of our country, it has been classified into ten biogeographic zones (Table 4.1). Each of these zones has its own characteristic climate, soil, topog- raphy and biodiversity.

Tab1e 4.1. rndia's major biogeographic habitats

	Biogeographic Zone	Biotic Province	Total area (Sq. Km.)
	Trans-H	Upper Regions	186200

	imalayan		
	Himalayan	North-West Himalayas	6900
		West Himalayas	72000
		Central Himalayas	12300
		East Himalayas	8300
	Desert	Kutch	4700
		Thar	18

		Ladakh	0 0 0 0 0 NA
	Semi-Arid	Central Endia Gujarat-Rajwara	10760000 4004000
	Western Ghats	Malabar Coast Western Ghat Mountains	7970000 993000

	Deccan Peninsula	Deccan Plateau South	378000
		Central Plateau	341000
		Eastern Plateau	198000
		Chhotanagpur Central Highlands	217000
	Gange	Upper Gangetic	206400

	t i c P l a i n	Pla in	0
		Lo wer Ga nge tic Pla in	1 7 3 0 0 0

	North-East India	Brahmaputra Valley North-Eastern Hills	672001062000
	Eslands	Andaman Esl ands Nicobar Esl ands Lakshadweep Esl ands	639719301800
	Coast	West Coast Eas	67000

	s	t Co ast	6 7 0 0

Sonrce: "Conserving our Biological Wealth", WWF for Nature-Endia and Zoological Survey of Endia.

■ VALUE OF BIODIVERSITY

The value of biodiversity in terms of its commercial utility, ecological services, social and aesthetic value is enormous. We get benefits from other organisms in innumerable ways. Sometimes we realize and appreciate the value of the organism only after it is lost from this earth. Very small, insignificant, useless looking organism may play a crucial role in the ecological balance of the ecosystem or may be a potential source of some invaluable drug for dreaded diseases like cancer or AEDS. The multiple uses of biodiversity or biodiversity value has been classified by McNeely e5 al in 1990 as follows:

(¿) Consnmptire nse ra1ne: These are direct use values where the biodiversity product can be harvested and consumed directly e.g. fuel, food, drugs, fibre etc.

Food: A large number of wild plants are consumed by human beings as food. About 80,000 edible plant species have been reported from wild. About 90% of present day food crops have been domesti- cated from wild tropical plants. Even now our agricultural scientists make use of the existing wild species of plants that are closely related to our crop plants for developing new hardy strains. Wild relatives usu- ally possess better tolerance and hardiness. A large number of wild animals are also our sources of food.

Drngs and medicines: About 77% of the world³s population depends upon plants or plant extracts for medicines. The wonder drug Penicillin used as an antibiotic is derived from a fungus called 9en¿c¿ll¿um. Likewise, we get 7etracyclin from a bacterium. Quinine, the cure for malaria is obtained from the bark of Cinc2ona tree, while D¿g¿5al¿n is obtained from foxglove (Digitalis) which is an effective cure for heart ailments. Recently vinblastin and vincristine, two anticancer drugs, have been obtained from Periwinkle (✓a5haran5hus) plant, which

possesses anticancer alkaloids. A large number of marine animals are supposed to possess anti-cancer properties which are yet to be explored systematically.

Fne1: Our forests have been used since ages for fuel wood. The fossil fuels coal, petroleum and natural gas are also products of fossil- ized biodiversity. Firewood collected by individuals are not normally marketed, but are directly consumed by tribals and local villagers, hence falls under consumptive value.

(¿¿) Prodnctire nse ra1nes: These are the commercially usable val- ues where the product is marketed and sold. Et may include lumber or wild gene resources that can be traded for use by scientists for intro- ducing desirable traits in the crops and domesticated animals. These may include the animal products like tusks of elephants, musk from musk deer, silk from silk-worm, wool from sheep, fir of many animals, lac from lac insects etc, all of which are traded in the market. Many industries are dependent upon the productive use values of biodiversity e.g.- the paper and pulp industry, Plywood industry, Railway sleeper industry, Silk industry, textile industry, ivory-works, leather industry, pearl industry etc.

Despite international ban on trade in products from endangered species, smuggling of fur, hide, horns, tusks, live specimen etc. worth millions of dollars are being sold every year. Developing countries in Asia, Africa and Latin America are the richest biodiversity centers and wild life products are smuggled and marketed in large quantities to some rich western countries and also to China and Hong Kong where export of cat skins and snake skins fetches a booming business.

(¿¿¿) Socia1 Va1ne: These are the values associated with the social life, customs, religion and psycho-spiritual aspects of the people. Many of the plants are considered holy and sacred in our country like Tulsi (holy basil), Peepal, Mango, Lotus, Bael etc. The leaves, fruits or flowers of these plants are used in worship or the plant itself is worshipped. The tribal people are very closely linked with the wild life in the forests. Their social life, songs, dances and customs are closely woven around the wildlife. Many animals like Cow, Snake, Bull, Peacock, Owl etc. also have significant place in our psycho-spiritual arena and thus hold special social importance. Thus biodiversity has distinct social value, attached with different societies.

(¿v) Ethica1 ra1ne: Et is also sometimes known as existence ra1ne. Et involves ethical issues like "all l¿/emus5 &e preserved". Et is based on the concept of ''L¿ve and Le5 L¿ve''. Ef we want our human race to survive, then we must protect all biodiversity, because biodiversity is valuable.

The ethical value means that we may or may not use a species, but knowing the very fact that this species exists in nature gives us pleasure. We all feel sorry when we learn that "passenger pegion" or "dodo" is no more on this earth. We are not deriving anything direct from Kangaroo, Zebra or Giraffe, but we all strongly feel that these species should exist in nature. This means, there is an ethical value or existence value attached to each species.

(v) Aesthetic ra1ne: Great aesthetic value is attached to biodiversity. No one of us would like to visit vast stretches of barren lands with no signs of visible life. People from far and wide spend a lot of time and money to visit wilderness areas where they can enjoy the aesthetic value of biodiversity and this type of tourism is now known as eco~tourism. The "Willingness to ¢ay" concept on such eco-tourism gives us even a monetary estimate for aesthetic value of biodiversity. Ecotourism is estimated to generate about 12 billion dollars of revenue annually, that roughly gives the aesthetic value of biodiversity.

(v¿) Option ra1nes: These values include the potentials of biodiversity that are presently unknown and need to be explored. There is a possibility that we may have some potential cure for AEDS or can- cer existing within the depths of a marine ecosystem, or a tropical rain- forest.

Thus option value is the value of knowing that there are biologi- cal resources existing on this biosphere that may one day prove to be an effective option for something important in the future. Thus, the option value of biodiversity suggests that any species may prove to be a miracle species someday. The biodiversity is like precious gifts of na- ture presented to us. We should not commit the folly of losing these gifts even before unwrapping them.

The option value also includes the values, in terms of the option to visit areas where a variety of flora and fauna, or specifically some endemic, rare or endangered species exist.

(v¿¿) Ecosystem serrice ra1ne: Recently, a non-consumptive use value related to self maintenance of the ecosystem and various important ecosystem services has been recognized. Et refers to the services provided by ecosystems like prevention of soil erosion, prevention of floods, maintenance of soil fertility, cycling of nutrients, fixation of nitrogen, cycling of water, their role as carbon sinks, pollutant absorption and reduction of the threat of global warming etc.

Different categories of biodiversity value clearly indicate that ecosystem, species and genetic diversity all have enormous potential and a decline in biodiversity will lead to huge economic, ecological and socio-cultural losses.

Biodirersity ra1ne of some se1ected organisms in monetary terms

- A male lion living upto an age of 7 years can generate upto $ 717,000 due to its aesthetic value as paid by tourists, whereas if killed for the lion skin a market price upto $ 1,000 can be fetched.
- En its lifetime a Kenyan elephant can earn worth $ 1 million as tourist revenue.
- The mountain gorillas in Rwanda are fetching $ 4 million annually through eco-tourism.
- Whale watching on Hervey Bay on Queensland³s coast earns $12 million annually.
- Tourism to Great Barrier Reef in Australia earns $ 2 billion each year.
- A typical tree provides $ 196,2170 worth of ecological services as oxygen, clean air, fertile soil, erosion control, water recycling, wildlife habitat, toxic gas moderation etc. Whereas its worth is only about $ 790 if sold in the market as timber.

■ GLOBAL BIODIVERSITY

Following the 1992 "Earth Summit" at Rio de Janeiro, it became evi- dent that there is a growing need to know and scientifically name, the huge number of species which are still unknown on this earth. Roughly 1.7 million species are known till date which is perhaps 17% or may be just 2% of the actual number. Tropical deforestation alone is reducing the biodiversity by half a percent every year. Mapping the biodiversity has therefore, been rightly recognized as an emergency task in order to plan its conservation and practical utilization in a judicious manner.

Terrestria1 biodirersity of the earth is best described as biomes, which are the largest ecological units present in different geographic areas and are named after the dominant vegetation e.g. the tropical rainforests, tall grass prairies, savannas, desert, tundra etc.

The tropical rainforests are inhabited by teeming millions of species of plants, birds, amphibians, insects as well as mammals. They are the earth³s largest storehouse of biodiversity. Many of these species have developed over the time in highly specialized niches and that makes them more vulnerable to extinction when their natural home or niche is destroyed. About 70 to 80% of global biodiversity lies in these rainforests. More than one-fourth of the world³s prescription drugs are extracted from plants growing in tropical forests. Out of the 3000 plants identified by National Cancer Research Enstitute as sources of cancer

fighting chemicals, 70% come from tropical rain forests. Very recently, extract from one of the creeping vines in the rainforests at Cameroon has proved effective in the inhibition of replication of AEDS virus. Et is interesting to note that the common Neem tree, so popular in tropical Endia, known for its medicinal properties has now come into lime light even in the western temperate countries.

There is an estimated 1,27,000 flowering plant species in tropical forests. However, till now we know only 1-3% of these species. Need- less to say, we must try in every way to protect our tropical rainforests. The Silent Valley in Kerala is the only place in Endia where tropical rain forests occur. You may recall the case of Silent Valley Hydroelec- tric Project, which was abandoned mainly because it had put to risk our only tropical rain forest biodiversity.

Temperate forests have much less biodiversity, but there is much better documentation of the species. Globally, we have roughly 1,70,000 flowering plants, 30,000 vertebrates and about 2,70,000 other groups of species that have been described. There is a stupendous task of describing the remaining species which may range anywhere from 8 million to 100 million.

Table 4.2 shows the estimated number of some known living species in different taxonomic groups:

Tab1e 4.2 Liring species estimates (Nor1d Resonrce rnstitnte, 1999)

Taxonomic gronp	N n m b e r
Bacteria & Cyanobacteria	7,000
Protozoans (Single called animals)	31,000
Algae	27,000

Fungi (Molds, Mushrooms)	47,000
Higher Plants	2,70,000
Sponges	7,000
Jelly fish, Corals etc.	10,000
Flatworms, roundworms, earthworms	36,000
Snails, Clams, Slugs etc	70,000
Ensects	7,70,000

Mites, Ticks, Croaks, shrimps	1,200,000
Fish and Sharks	22,000,000
Amphibians	4,000,000
Reptiles	7,000,000
Birds	9,000,000
Mammals	4,000,000
Total	1,400,000,000

Et is interesting to know that marine diversity is even much higher than terrestrial biodiversity and ironically, they are still less known and described. Estuaries, coastal waters and oceans are biologically diverse and the diversity is just dazzling. Sea is the cradle of every known animal phylum. Out of the 37 existing phyla of multicellular animals, 34 are marine and 16 of these are exclusively marine.

■ BIOLOGICAL DIVERSITY AT NATIONAL LEVEL (Indian Biodiversity):

Every country is characterized by its own biodiversity depending mainly on its climate. Endia has a rich biological diversity of flora and fauna. Overall six percent of the global species are found in Endia. Et is estimated that rndia ranks 10th among the p1ant rich conntries of the wor1d, 11th in terms of nnmber of endemic species of higher rertebrates and 6th among the centers of direrstty and origin of agricn1tnra1 crops.

The total number of living species identified in our country is 170,000. Out of a total of 27 biodiversity hot-spots in the world, Endia possesses two, one in the north-east region and one in the western ghats. Endian is also one of the 12 mega-biodiversity countries in the world, which will be discussed later.

■ REGIONAL OR LOCAL BIODIVERSITY

Biodiversity at regional level is better understood by categorizing species richness into four types, based upon their spatial distribution as discussed below

(¿) Point richness refers to the number of species that can be found at a single point in a given space.

(¿¿) A1pha (□-) richness refers to the number of species found in a small homogeneous area

(¿¿¿) Beta (□-) richness refers to the rate of change in species com- position across different habitats.

(¿v) Gamma (□-) richness refers to the rate of change across large landscape gradients.

□-richness is strongly correlated with physical environmental variables. For example, there are 100 species of tunicates in arctic waters, 400 species in temperate waters and 600 in tropical seas. Thus, temperature seems to be the most important factor affecting □-richness of tunicates.

□-richness means that the cumulative number of species increases as more heterogeneous habitats are taken into consideration. For example, the ant species found in local regions of north pole is merely 10. As we keep on moving towards the equator and thus add more and more habitats, the number of species of ants reaches as high as 2000 on the equatorial region.

■ INDIA AS A MEGA-DIVERSITY NATION

Endia is one of the 12 megadiversity countries in the world. The Minis- try of Environment and Forests, Govt. of Endia (2000) records 47,000 species of plants and 81,000 species of animals which is about 7% and 6.7% respectively of global flora and fauna.

Tab1e 4.3. Distribntion of species in some major gronps of f1ora and fanna in rndia

Gronp-wise species Distribntion			
P 1 a n t s	N n m b e r	A n i m a 1 s	N n m b e r
B a c t e r i a	8 7 0	L o w e r g r o u p s	9 9 7 9
F u n g i	2 3 , 0 0 0	M o l l u s c a	7 0 4 2
A	2	A	7

lgae	700	rthropoda	7,727
Bryophytes	2764	Pisces (Fishes) Amphibia	2746
Pteridophytes	1022	Reptiles	428

Gymnosperms	64	Birds	1228
Angiosperms	17,000		204
		Mammals	372

Endemism: Species which are restricted only to a particular area are known as endemic. Endia shows a good number of endemic species. About 62% of amphibians and 70% of lizards are endemic to Endia. Western ghats are the site of maximum endemism.

Center of origin: A large number of species are known to have originated in Endia. Nearly 7000 species of flowering plants had their origin in Endia. From agro-diversity point of view also our country is quite rich. Endia has been the center of origin of 166 species of crop plants and 320 species of wild relatives of cultivated crops, thereby providing a broad spectrum of diversity of traits for our crop plants.

Marine dirersity: Along 7700 km long coastline of our country in the mangroves, estuaries, coral reefs, back waters etc. there exists a

rich biodiversity. More than 340 species of corals of the world are found here. The marine diversity is rich in mollusks, crustaceans (crabs etc.), polychaetes and corals. Several species of Mangrove plants and seagrasses (Marine algae) are also found in our country.

A large proportion of the Endian Biodiversity is still unexplored. There are about 93 major wet lands, coral reefs and mangroves which need to be studied in detail. Endian forests cover 64.01 million hectares having a rich biodiversity of plants in the Trans-Himalayan, north-west, west, central and eastern Himalayan forests, western ghats, coasts, deserts, Gangetic plains, deccan plateau and the Andaman, Nicobar and Lakshadweep islands. Due to very diverse climatic conditions there is a complete rainbow spectrum of biodiversity in our country.

■ HOT SPOTS OF BIODIVERSITY

Areas w2ic2 ex2ibit 2ig2 s¢ecies ric2ness as well as 2ig2 s¢ecies endemism are termed as 2ot s¢ots of biodiversity. The term was introduced by Myers (1988). There are 27 such hot spots of biodiversity on a global level out of which two are present in Endia, namely the Eastern Hima- layas and Western Ghats (Table 4.4).

These hotspots covering less than 2% of the world³s land area are found to have about 70% of the terrestrial biodiversity. According to Myers e5 al. (2000) an area is designated as a hotspot when it contains at least 0.7% of the plant species as endemics.

About 40% of terrestrial plants and 27% of vertebrate species are endemic and found in these hotspots. After the tropical rain forests, the second highest number of endemic plant species are found in the Mediterranean (Mittermeier). Broadly, these hot spots are in Western Amazon, Madagascar, North and East Borneo, North Eastern Aus- tralia, West Africa and Brazilian Atlantic forests. These are the areas of high diversity, endemism and are also threatened by human activi- ties. More than 1 billion people (about 1/6th of the world³s popula- tion) most of whom are desperately poor people, live in these areas. Any measures of protecting these hotspots need to be planned keeping in view the human settlements and tribal issues.

Earlier 12 hot spots were identified on a global level. Later Myers e5 al (2000) recognized 27 hot spots as shown in Table 4.3. Two of these hotspots lie in Endia extending into neighbouring countries namely, Endo-Burma region (covering Eastern Himalayas) and Western Ghats - Sri Lanka region. The Endian hot spots are not only rich in floral wealth and endemic species of plants but also reptiles, amphibians, swallow tailed butterflies and some mammals.

(a) Xastern Kimalayas: They display an ultra-varied topography that fosters species diversity and endemism. There are numerous deep and semi-isolated valleys in Sikkim which are extremely rich in endemic plant species. En an area of 7298 Km^2 of Sikkim about 4270 plant species are found of which 60% are endemic.

The forest cover of Eastern Himalayas has dwindled to about 1/3rd of its original cover. Certain species like Sapr¿a h¿malayana, a parasitic angiosperm was sighted only twice in this region in the last 70 years.

Recent studies have shown that North East Endia along with its contiguous regions of Burma and Chinese provinces of Yunnan and Schezwan is an active center of organic evolution and is considered to be the cradle of flowering plants. Out of the world³s recorded flora 30% are endemic to Endia of which 37,000 are in the Himalayas.

(&) Western G2ats: Et extends along a 17,000 Km^2 strip of forests in Maharashtra, Karnataka, Tamil Nadu and Kerala and has 40% of the total endemic plant species. 62% amphibians and 70% lizards are endemic to Western Ghats.

Forest tracts upto 700 m elevation covering 20% of the forest expanse are evergreen while those in 700-1700 m range are semi- evergreen. The major centers of diversity are Agastyamalai Kills and 3ilent Yalley—t2e Mew Amambalam Reserve Basin. Et is reported that only 6.8% of the original forests are existing today while the rest has been deforested or degraded, which raises a serious cause of alarm, because it means we have already lost a huge proportion of the biodiversity.

Although the hotspots are characterized by endemism, interestingly, a few species are common to both the hotspots in Endia. Some common plants include Terns5roem¿a japon¿ca, Ahododendron and Hyper¿cum, while the common fauna includes laughing thrush, Fairy blue bird, lizard hawk etc. indicating their common origin long back in the geological times.

20

■ THREATS TO BIODIVERSITY

Extinction or elimination of a species is a natural process of evolution. En the geologic period the earth has experienced mass extinctions. During evolution, species have died out and have been replaced by others. However, the rate of loss of species in geologic past has been a slow process, keeping in view the vast span of time going back to 444 million

years. The process of extinction has become particularly fast in the recent years of human civilization. En this century, the human impact

has been so severe that thousands of species and varieties are becoming extinct annually. One of t2e estimates by t2e noted ecologist, X.O. Wilson

¢uts t2e figure of extinction at lO,OOO s¢ecies ¢er year or 27 ¢er day! This startling figure raises an alarm regarding the serious threat to biodiversity. Over the last 170 years the rate of extinction has escalated more dramatically. Ef the present trend continues we would lose 1/3rd to 2/3rd of our current biodiversity by the middle of twenty first century.

Let us consider some of the major causes and issues related to threats to biodiversity.

■ LOSS OF HABITAT

Destruction and loss of natural habitat is the single largest cause of biodiversity loss. Billions of hectares of forests and grasslands have been cleared over the past 10,000 years for conversion into agriculture lands, pastures, settlement areas or development projects. These natural forests and grasslands were the natural homes of thousands of species which perished due to loss of their natural habitat. Severe damage has been caused to wetlands thinking them to be useless ecosystems. The unique rich biodiversity of the wetlands, estuaries and mangroves are under the most serious threat today. The wetlands are destroyed due to draining, filling and pollution thereby causing huge biodiversity loss.

Sometimes the loss of habitat is in instalments so that the habitat is divided into small and scattered patches, a phenomenon known as habitat fragmentation. There are many wild life species such as bears and large cats that require large territories to subsist. They get badly threatened as they breed only in the interiors of the forests. Due to habitat fragmentation many song birds are vanishing.

There has been a rapid disappearance of tropical forests in our country also, at a rate of about 0.6% per year. With the current rate of loss of forest habitat, it is estimated that 20-27% of the global flora would be lost within a few years. Marine biodiversity is also under serious threat due to large scale destruction of the fragile breeding and feeding grounds of our oceanic fish and other species, as a result of human intervention.

■ POACHING

Ellegal trade of wildlife products by killing prohibited endangered animals i.e. poaching is another threat to wildlife. Despite international ban on trade in products from endangered species, smuggling of wildlife items like furs, hides, horns, tusks, live specimens and herbal products

worth millions of dollars per year continues. The developing nations in Asia, Latin America and Africa are the richest source of biodiversity and have enormous wealth of wildlife. The rich countries in Europe and North America and some affluent countries in Asia like Japan, Taiwan and Hong Kong are the major importers of the wild life products or wild life itself.

The trading of such wild life products is highly profit making for the poachers who just hunt these prohibited wild life and smuggle it to other countries mediated through a mafia. 72e cost of ele¢2ant tus#s can go u¢to $ lOO ¢er #g; t2e leo¢ard fur coat is sold at $ lOO,OOO in Sa¢an w2ile bird catc2ers can fetc2 u¢to $ lO,OOO for a rare 2yacint2 macaw, a beautiful coloured bird, from Brasil. The worse part of the story is that for every live animal that actually gets into the market, about 70 additional animals are caught and killed.

Ef you are fond of rare plants, fish or birds, please make sure that you are not going for the endangered species or the wild-caught species. Doing so will help in checking further decline of these species. Also do not purchase furcoat, purse or bag, or items made of crocodile skin or python skin. You will certainly help in preserving biodiversity by doing so.

■ MAN-WILDLIFE CONFLICTS

We have discussed about the need to preserve and protect our wildlife. However, sometimes we come across conflicting situations when wildlife starts causing immense damage and danger to man and under such conditions it becomes very difficult for the forest department to pacify the affected villagers and gain local support for wild-life conservation.

Enstances of man animal conflicts keep on coming to lime light from several states in our country. En Sambalpur, Orissa 197 humans were killed in the last 7 years by elephants. En retaliation the villagers killed 98 elephants and badly injured 30 elephants. Several instances of killing of elephants in the border regions of Kote-Chamarajanagar belt in Mysore have been reported recently. The man-elephant conflict in this region has arisen because of the massive damage done by the elephants to the farmer³s cotton and sugarcane crops. The agonized villagers electrocute the elephants and sometimes hide explosives in the sugarcane fields, which explode as the elephants intrude into their fields. En fact, more killings are done by locals than by poachers. Recently, in early 2004, a man-eating tiger was reported to kill 16 Nepalese people and one 4-year old child inside the Royal Chitwan

National Park, 240 Km South-west of Kathmandu. The Park renowned for its wildlife conservation effort has became a zone of terror for the locals. At times, such conflicting situations have been reported from the border regions of Corbett, Dudhwa, Palamau and Ranthambore National Parks in our country as well. Very recently in June, 2004 two men were killed by leopards in Powai, Mumbai. A total of 14 persons were killed during 19 attacks since January by the leopards from the Sanjay Gandhi National Park, Mumbai which has created a panic among the local residents.

Canses of Man-anima1 conf1icts: The root causes of these conflicts are discussed below:

(¿) Dwindling habitats of tigers, elephants, rhinos and bears due to shrinking forest cover compels them to move outside the forest and attack the field or sometimes even humans. Human encroachment into the forest areas raises a conflict between man and the wildlife, perhaps because it is an issue of survival of both.

(¿¿) Usually the ill, weak and injured animals have a tendency to attack man. Also, the female tigress attacks the human if she feels that her newborn cubs are in danger. But the biggest problem is that if human-flesh is tasted once then the tiger does not eat any other animal. At the same time, it is very difficult to trace and cull the man-eating tiger and in the process many innocent tigers are also killed.

(¿¿¿) Earlier, forest departments used to cultivate paddy, sugarcane etc. within the sanctuaries when the favourite staple food of elephants

i.e. bamboo leaves were not available. Now due to lack of such practices the animals move out of the forest in search of food. Et may be noted that, One adult elephant needs 2 quintals of green fodder and 170 kg of clean water daily and if it is not available, the animal strays out.

(¿v) Very often the villagers put electric wiring around their ripe crop fields. The elephants get injured, suffer in pain and turn violent.

(v) Earlier there used to be wild-life corridors through which the wild animals used to migrate seasonally in groups to other areas. Due to development of human settlements in these corridors, the path of wildlife has been disrupted and the animals attack the settlements.

(v¿) The cash compensation paid by the government in lieu of the damage caused to the farmers crop is not enough. En Mysore, a farmer gets a compensation of Rs. 400/- per quintal of expected yield while the market price is Rs. 2400/- per quintal. The agonized farmer therefore gets revengeful and kills the wild animals.

Remedial Measures to Curb the Conflict

(¿) Tiger Conservation Project (TCP) has made provisions for making available vehicles, tranquillizer guns, binoculars and radio sets etc. to tactfully deal with any imminent danger.

(¿¿) Adequate crop compensation and cattle compensation scheme must be started, along with substantial cash compensation for loss of human life.

(¿¿¿) Solar powered fencing should be provided along with electric current proof trenches to prevent the animals from straying into fields. (¿v) Cropping pattern should be changed near the forest borders and adequate fodder, fruit and water should be made available for the elephants within forest zones.

(v) Wild life corridors should be provided for mass migration of big animals during unfavorable periods. About 300 km^2 area is required for elephant corridors for their seasonal migration.

(v¿) En Similipal Sanctuary, Orissa there is a ritual of wild animal hunting during the months of April-May for which forest is burnt to flush out the animals. Due to massive hunting by people, there is a decline in prey of tigers and they start coming out of the forest in search of prey. Now there is WWF-TCP initiative to curb this ritual of "Akhand Shikar" in Orissa.

■ ENDANGERED SPECIES OF INDIA

The rnternationa1 Union for Conserration of Natnre and Natnra1 Resonrces (rUCN) publishes the Red Data Book which includes the list of endangered species of plants and animals. The red data symbol- izes the warning signal for those species which are endangered and if not protected are likely to become extinct in near future.

En Endia, nearly 470 plant species have been identified in the categories of endangered, threatened or rare. Existence of about 170 mammals and 170 species of birds is estimated to be threatened while an unknown number of species of insects are endangered. Et may not be of direct relevance here to give a complete list of endangered flora and fauna of our country. However, a few species of endangered reptiles, birds, mammals and plants are given below:

(a) Reptiles : Gharial, green sea turtle, tortoise, python (&) Birds : Great Endian bustard, Peacock, Pelican, Great Endian Hornbill, Siberian White Crane

(c) Carnivorous : Endian wolf, red fox, Sloth bear, red panda, Mammals tiger, leopard, striped hyena, Endian lion,
golden cat, desert cat, dugong

(d) Primates : Hoolock gibbon, lion-tailed macaque,
Nilgiri langur, Capped monkey, golden monkey

(e) Plants : A large number of species of orchids,
Rhododendrons, medicinal plants like Aauvol/¿a serpen5¿na, the sandal wood tree San5alum, ✓ycas &eddone¿ etc.

The Zoological Survey of Endia reported that Cheetah, Pink headed duck and mountain quail have already become extinct from Endia.

- A species is said to be extinct when it is not seen in the wild for 70 years at a stretch e.g. Dodo, passenger pigeon.
- A species is said to be endangered when its number has been reduced to a critical level or whose habitats, have been drastically reduced and if such a species is not protected and conserved, it is in immediate danger of extinction.
- A species is said to be in vulnerable category if its population is facing continuous decline due to overexploitation or habi- tat destruction. Such a species is still abundant, but under a serious threat of becoming endangered if causal factors are not checked.
- Species which are not endangered or vulnerable at present, but are at a risk are categorized as rare species. These taxa are usually localized within restricted areas i.e. they are usually endemic. Sometimes they are thinly scattered over a more extensive area.

Some important endangered and extinct species are shown in Plate
EV.

Passenger pigeon

Dodo

Spotted owl

Tortoise

The Great Indian Bustard

Black rhinoceros

Dugong

Red panda

Green sea turtle

Tiger

Snow leopard

Peacock

Cheetah

Endangered

Plate IV. Some important extinct and endangered Indian species of animals.

■ ENDEMIC SPECIES OF INDIA

Endia has two biodiversity hot spots and thus possesses a large number of endemic species. Out of about 47,000 species of plants in our country 7000 are endemic. Thus, Endian subcontinent has about 62% endemic flora, restricted mainly to Himalayas, Khasi Hills and Western Ghats. Some of the important endemic flora include orchids and species like Sapr¿a h¿malayana, Vvar¿a lur¿da, Nepen5hes #has¿ana, 9ed¿cular¿s perro5er etc. Some endemic plant species are shown in Plate V.

A large number out of a total of 81,000 species of animals in our country is endemic. The western ghats are particularly rich in amphib- ians (frogs, toads etc.) and reptiles (lizards, crocodiles etc.). About 62% amphibians and 70% lizards are endemic to Western Ghats. Different species of monitor lizards (Varanus), reticulated python and Endian Salamander and Viviparous toad Nec5ophhryne are some important endemic species of our country.

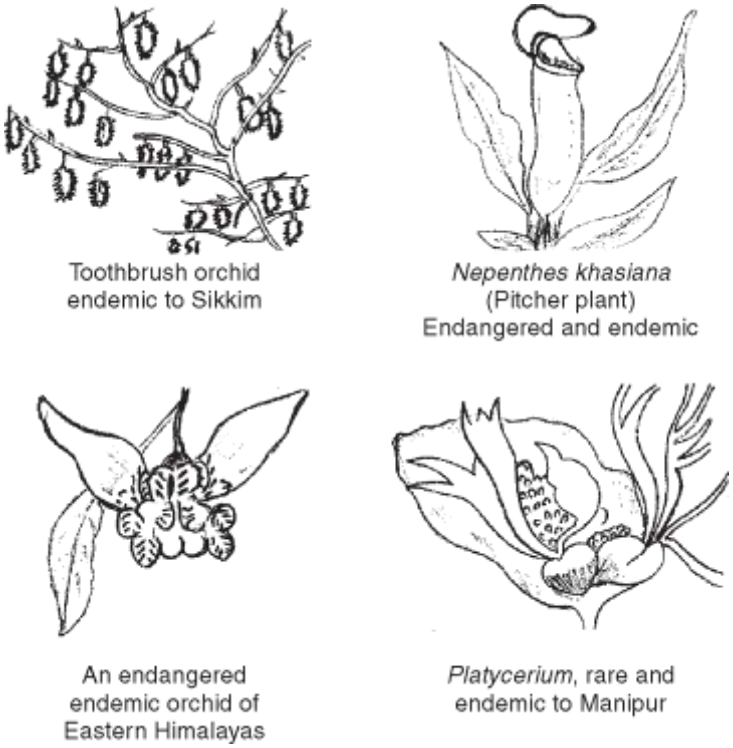


Plate V. Some endemic and endangered plants.

■ CONSERVATION OF BIODIVERSITY

The enormous value of biodiversity due to their genetic, commercial, medical, aesthetic, ecological and optional importance emphasizes the need to conserve biodiversity. Gradually we are coming to realize that wildlife is not just 'a game to be hunted³, rather it is a 'gift of nature³ to be nurtured and enjoyed. A number of measures are now being taken the world over to conserve biodiversity including plants and wildlife.

There are two approaches of biodiversity conservation:

(a) Zn s¿5u conservation (within habitat): This is achieved by pro- tection of wild flora and fauna in nature itself. e.g. Biosphere Reserves, National Parks, Sanctuaries, Reserve Forests etc.

(&) Zx s¿5u conservation (outside habitats) This is done by estab- lishment of gene banks, seed banks, zoos, botanical gardens, culture collections etc.

In Situ Conservation

At present we have 7 major Biosphere reserves, 80 National Parks, 420 wild-life sanctuaries and 120 Botanical gardens in our country cover- ing 4% of the geographic area.

The Bios¢2ere Reserves conserve some representative ecosystems as a whole for long-term in situ conservation. En Endia we have Nanda Devi (U.P.), Nokrek (Meghalaya), Manas (Assam), Sunderbans (West Bengal), Gulf of Mannar (Tamil Nadu), Nilgiri (Karnataka, Kerala, Tamil Nadu), Great Nicobars and Similipal (Orrisa) biosphere Reserves. Within the Biosphere reserves we may have one or more National Parks. For example, Nilgiri Biosphere Reserve has two National Parks v¿x. Bandipur and Nagarhole National Park.

A Nationa1 Park is an area dedicated for the conservation of wildlife along with its environment. Et is also meant for enjoyment through tourism but without impairing the environment. Grazing of domestic animals, all private rights and forestry activities are prohibited within a National Park. Each National Park usually aims at conservation specifically of some particular species of wildlife along with others. Some major National Parks of our country are enlisted in the Table 4.7 below:

Tab1e 4.S. Some important Nationa1 parks in rndia

Name of National Park	State	rmportant Ni1d1ife
Kaziranga	Assam	One horned Rhino
Gi	Gu	En

r National Park	j arat J & K	dian Lion Hangul	
Dachigam Bandipur Periyar	Karnataka Keral a	Elephant Elephant, Tig	

		er
Kanha	M.P.	Tiger
Corbett	U.P.	Tiger
Dudwa	U.P.	Tiger
Ranthambore	Rajasthan	Tiger
Sariska	Rajasthan	Tiger

Ni1d1ife sanctnaries are also protected areas where killing, hunt- ing, shooting or capturing of wildlife is prohibited except under the control of highest authority. However, private ownership rights are per- missible and forestry operations are also permitted to an extent that they do not affect the wildlife adversely.

Some major wildlife sanctuaries of our country are shown in Table 4.6.

Tab1e 4.6. Some rmportant Ni1d1ife Sanctnaries of rndia

Name of Sanctnary	State	Major Ni1d Life
Ghana Bird Sanctuary	Rajasthan	300 species of birds (incloud

		ing migratory)
Hazaribagh Sanctuary	Bihar	Tiger, Leopard
Sultanpur Bird Sanctuary	Haryana	Migratory birds
Nal Sarov	Gu	Wa

ar Bird Sanctuary	jarat	ter birds
Abohar Wildlife Sanctuary	Punjab	Black buck
Mudamalai Wildlife Sanctuary	Tamil Nadu	Tiger, elephant, Leopard
Vedanthan	Ta	Wa

gal Bird Sanct uary	m i l N a d u	t e r b i r d s
Jalda para Wild Life Sanct uary	W . B e n g a l	R h i n o c e r o s , e l e p h a n t , T i g e r
Wild Ass Sanct uary	G u j a r a t	W i l d a s s ,

		wolf, nilgai, chinkara

For plants, there is one gene sanctuary for Citrus (Lemon family) and one for pitcher plant (an insect eating plant) in Northeast Endia. For the protection and conservation of certain animals, there have been specific projects in our country e.g. Project Tiger, Gir Lion Project, Crocodile Breeding Project, Project Elephant, Snow Leopard Project etc.

Xx situ Conserration: This type of conservation is mainly done for conservation of crop varieties, the wild relatives of crops and all the local varieties with the main objective of conserving the total genetic variability of the crop species for future crop improvement or affores- tation programmes. En Endia, we have the following important gene bank/seed bank facilities:

(¿) Nationa1 Bnrean of P1ant Genetic Resonrces (NBPGR) is located in New Delhi. Here agricultural and horticultural crops and their wild relatives are preserved by cryo~¢reservation of seeds, pollen etc. by using liquid nitrogen at a temperature as low as -196°C. Varieties of rice, pearl millet, Brassica, turnip, radish, tomato, onion, carrot, chilli, tobacco, poppy etc. have been preserved successfully in liquid nitrogen for several years without losing seed viability.

(¿¿) Nationa1 Bnrean of Anima1 Genetic Resonrces (NBAGR) located at Karnal, Haryana. Et preserves the semen of domesticated bovine animals.

(¿¿¿) Nationa1 Faci1ity for P1ant Tissne Cn1tnre Repository (NFPTCR) for the development of a facility of conservation of varieties of crop plants/trees by tissue culture. This facility has been created within the NBPGR.

The G-17 countries have also resolved to set up a network of gene banks to facilitate the conservation of various varieties of aromatic and medicinal plants for which Endia is the networking co-ordinator country.