

- Structure and function of an ecosystem.
- Producers, consumers and decomposers.
- Energy flow in the ecosystem.
- Ecological succession.
- Food chains, food webs and ecological pyramids.
- Introduction, types, characteristic features, structure and function of the

following ecosystem :-

- a. Forest ecosystem
- b. Grassland ecosystem
- c. Desert ecosystem
- d. Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

(6 lectures)

Unit 4 : Biodiversity and its conservation

- Introduction – Definition : genetic, species and ecosystem diversity.
- Biogeographical classification of India
- Value of biodiversity : consumptive use, productive use, social, ethical, aesthetic and option values
- Biodiversity at global, National and local levels.
- India as a mega-diversity nation

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Foreword

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This textbook deals with major environmental concerns that have been identified as important areas where background information is essential for a better understanding of our environment. It stresses on a balanced view of issues that affect our daily lives. These issues are related to the conflict between existing 'development' strategies and the need for 'environmental conservation'. Unlike most other textbooks, it not only makes the reader better informed on these concerns, but is expected to lead him or her towards positive action to improve the environment.

There are three reasons for studying the state of the environment. Firstly is the need for information that clarifies modern environmental concepts such as the need to conserve biodiversity, the need to lead more sustainable lifestyles and the need to use resources more equitably. Secondly, there is a need to change the way in which we view our environment by a practical approach based on observation and self-learning. Thirdly there is the need to create a concern for our environment that will trigger pro-environmental action, including activities we can do in our daily life to protect it.

1.1 DEFINITION, SCOPE AND IMPORTANCE

1.1.1 Definition

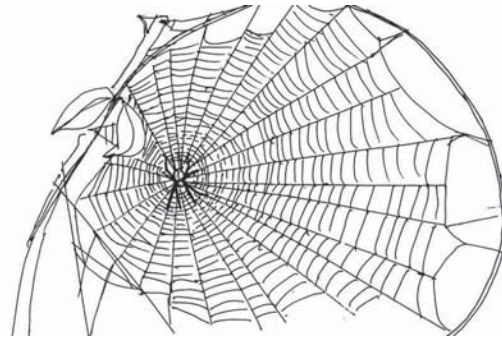
Environmental studies deals with every issue that affects an organism. It is essentially a multidisciplinary approach that brings about an appreciation of our natural world and human impacts on its integrity. It is an applied science as it seeks practical answers to making human civilization sustainable on the earth's finite resources.

Its components include biology, geology, chemistry, physics, engineering, sociology, health, anthropology, economics, statistics, computers and philosophy.

1.1.2 Scope

As we look around at the area in which we live, we see that our surroundings were originally a natural landscape such as a forest, a river, a mountain, a desert, or a combination of these elements. Most of us live in land crops that have been heavily modified by human beings, in villages, towns and cities. But even those of us who live in cities get our food supply from the surrounding villages and these in turn are dependent on natural landscapes such as forests, grasslands, rivers, seashores, for resources such as water for agriculture, fuel wood, fodder, and fish. Thus our daily lives are linked with our surroundings and inevitably affects them. We use water to drink and for other day-to-day activities. We breathe air, we use resources from which food is made and we depend on the community of living plants and animals which form a web of life, of which we are also a part. Everything around us forms our environment and our lives depend on keeping its vital systems as intact as possible.

Our dependence on nature is so great that we cannot continue to live without protecting the



earth's environmental resources. Thus most traditions refer to our environment as 'Mother Nature' and most traditional societies have learned that respecting nature is vital for their livelihoods. This has led to many cultural practices that helped traditional societies protect and preserve their natural resources. Respect for nature and all living creatures is not new to India. All our traditions are based on these values. Emperor Ashoka's edict proclaimed that all forms of life are important for our well being in Fourth century BC.

Over the past 200 years however, modern societies began to believe that easy answers to the question of producing more resources could be provided by means of technological innovations. For example, though growing more food by using fertilizers and pesticides, developing better strains of domestic animals and crops, irrigating farmland through mega dams and developing industry, led to rapid economic growth, the ill effects of this type of development, led to environmental degradation.

The industrial development and intensive agriculture that provides the goods for our increasingly consumer oriented society uses up large amounts of **natural resources** such as water, minerals, petroleum products, wood, etc. **Non-renewable resources**, such as minerals and oil are those which will be exhausted in the future if we continue to extract these without a thought for subsequent generations. **Renew-**

Zoological Survey of India (ZSI): The ZSI was established in 1916. Its mandate was to do a systematic survey of fauna in India. It has over the years collected 'type specimens' on the bases of which our animal life has been studied over the years. Its origins were collections based at the Indian Museum at Calcutta, which was established in 1875. Older collections of the Asiatic Society of Bengal, which were made between 1814 and 1875, as well as those of the Indian Museum made between 1875 and 1916 were then transferred to the ZSI. Today it has over a million specimens! This makes it one of the largest collections in Asia. It has done an enormous amount of work on taxonomy and ecology. It currently operates from 16 regional centers.

1.2.2 People in Environment

There are several internationally known environmental thinkers. Among those who have made landmarks, the names that are usually mentioned are Charles Darwin, Ralph Emerson, Henry Thoreau, John Muir, Aldo Leopold, Rachel Carson and EO Wilson. Each of these thinkers looked at the environment from a completely different perspective. **Charles Darwin** wrote the 'Origin of Species', which brought to light the close relationship between habitats and species. It brought about a new thinking of man's relationship with other species that was based on evolution. Alfred Wallace came to the same conclusions during his work. **Ralph Emerson** spoke of the dangers of commerce to our environment way back in the 1840s. **Henry Thoreau** in the 1860s wrote that the wilderness should be preserved after he lived in the wild for a year. He felt that most people did not care for nature and would sell it off for a small sum of money. **John Muir** is remembered as having saved the great ancient sequoia trees in California's forests. In the 1890s he formed the Sierra club, which is a major conservation NGO in the USA. **Aldo Leopold** was a forest official

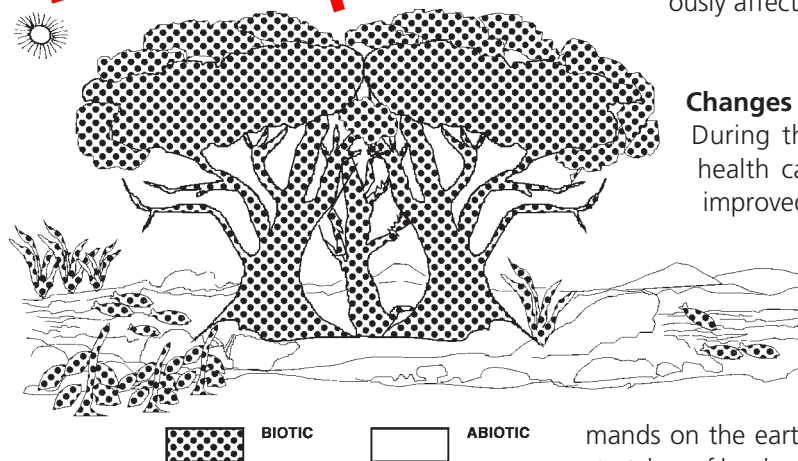
in the US in the 1920s. He designed the early policies on wilderness conservation and wildlife management. In the 1960s **Rachel Carson** published several articles that caused immediate worldwide concern on the effects of pesticides on nature and mankind. She wrote a well-known book called 'Silent Spring' which eventually led to a change in Government policy and public awareness. **EO Wilson** is an entomologist who envisioned that biological diversity was a key to human survival on earth. He wrote 'Diversity of Life' in 1993, which was awarded a prize for the best book published on environmental issues. His writings brought home to the world the risks to mankind due to man made disturbances in natural ecosystems that are leading to the rapid extinction of species at the global level.

There have been a number of individuals who have been instrumental in shaping the environmental history in our country. Some of the well-known names in the last century include environmentalists, scientists, administrators, legal experts, educators and journalists. **Salim Ali's** name is synonymous with ornithology in India and with the Bombay Natural History Society (BNHS). He also wrote several great books including the famous 'Book of Indian Birds'. His autobiography, 'Fall of a Sparrow' should be read by every nature enthusiast. He was our country's leading conservation scientist and influenced environmental policies in our country for over 50 years. **Indira Gandhi** as PM has played a highly significant role in the preservation of India's wildlife. It was during her period as PM, that the network of PAs grew from 65 to 298! The Wildlife Protection Act was formulated during the period when she was PM and the Indian Board for Wildlife was extremely active as she personally chaired all its meetings. India gained a name for itself by being a major player in CITES and other International Environmental Treaties and Accords during her tenure. BNHS frequently used her good will to get conservation action initiated by the Government.

2.1 INTRODUCTION

Our environment provides us with a variety of goods and services necessary for our day to day lives. These **natural resources** include, air, water, soil, minerals, along with the climate and solar energy, which form the non-living or '**abiotic**' part of nature. The '**biotic**' or living parts of nature consists of plants and animals, including microbes. Plants and animals can only survive as communities of different organisms, all closely linked to each in their own **habitat**, and requiring specific abiotic conditions. Thus, forests, grasslands, deserts, mountains, rivers, lakes and the marine environment all form habitats for specialised communities of plants and animals to live in. Interactions between the abiotic aspects of nature and specific living organisms together form **ecosystems** of various types. Many of these living organisms are used as our food resources. Others are linked to our food less directly, such as pollinators and dispersers of plants, soil animals like worms, which recycle nutrients for plant growth, and fungi and termites that break up dead plant material so that micro-organisms can act on the remains to reform soil nutrients.

History of our global environment: About ten thousand years ago, when mankind changed from a hunter-gatherer, living in wilderness areas such as forests and grasslands, into an agriculturalist and pastoralist, we began to change the environment to suit our own requirements. As our ability to grow food and use domestic animals grew, these 'natural' ecosystems were developed into agricultural land. Most traditional agriculturists depended extensively on rain, streams and rivers for water. Later they began to use wells to tap underground water sources and to impound water and created irrigated land by building dams. Recently we began to use fertilizers and pesticides to further boost the production of food from the same amount of land. However we now realize that all this has led to several undesirable changes in our environment. Mankind has been overusing and depleting natural resources. The over-intensive use of land has been found to exhaust the capability of the ecosystem to support the growing demands of more and more people, all requiring more intensive use of resources. Industrial growth, urbanisation, population growth and the enormous increase in the use of consumer goods, have all put further stresses on the environment. They create great quantities of solid waste. Pollution of air, water and soil have begun to seriously affect human health.



Changes in land and resource use:

During the last 100 years, a better health care delivery system and an improved nutritional status has led to rapid population growth, especially in the developing countries. This phenomenal rise in human numbers has, in the recent past, placed great demands on the earth's natural resources. Large stretches of land such as forests, grasslands and wetlands have been converted into intensive agriculture. Land has been taken for industry and

the urban sectors. These changes have brought about dramatic alterations in land-use patterns and rapid disappearance of valuable natural ecosystems. The need for more water, more food, more energy, more consumer goods, is not only the result of a greater population, but also the result of over-utilization of resources by people from the more affluent societies, and the affluent sections of our own.

Industrial development is aimed at meeting growing demands for all consumer items. However, these consumer goods also generate waste in ever larger quantities. The growth of industrial complexes has led to a shift of people from their traditional, sustainable, rural way of life to urban centers that developed around industry. During the last few decades, several small urban centers have become large cities, some have even become giant mega-cities. This has increased the disparity between what the surrounding land can produce and what the large number of increasingly consumer-oriented people in these areas of high population density consume. Urban centers cannot exist without resources such as water from rivers and lakes, food from agricultural areas, domestic animals from pasture lands and timber, fuel wood, construction material and other resources from forests. Rural agricultural systems are dependent on forests, wetlands, grasslands, rivers and lakes. The result is a movement of natural resources from the wilderness ecosystems and agricultural sector to the urban user. The magnitude of the shift of resources has been increasing in parallel with the growth of industry and urbanisation, and has changed natural landscapes all over the world. In many cases, this has led to the rapid development of the urban economy, but to a far slower economic development for rural people and serious impoverishment of the lives of wilderness dwellers. The result is a serious inequality in the distribution of resources among human beings, which is both unfair and unsustainable.

Earth's Resources and Man: The resources on which mankind is dependent are provided by various sources or 'spheres'.

1) Atmosphere

- Oxygen for human respiration (metabolic requirements).
- Oxygen for wild fauna in natural ecosystems and domestic animals used by man as food.
- Oxygen as a part of carbon dioxide, used for the growth of plants (in turn are used by man).

The atmosphere forms a protective shell over the earth. The lowest layer, the troposphere, the only part warm enough for us to survive in, is only 12 kilometers thick. The stratosphere is 50 kilometers thick and contains a layer of sulphates which is important for the formation of rain. It also contains a layer of ozone, which absorbs ultra-violet light known to cause cancer and without which, no life could exist on earth. The atmosphere is not uniformly warmed by the sun. This leads to air flows and variations in climate, temperature and rainfall in different parts of the earth. It is a complex dynamic system. If its nature is disrupted it affects all mankind. Most air pollutants have both global and regional effects.

Living creatures cannot survive without air even for a span of a few minutes. To continue to support life, air must be kept clean. Major pollutants of air are created by industrial units that release various gases such as carbon dioxide, carbon monoxide and toxic fumes into the air. Air is also polluted by burning fossil fuels. The buildup of carbon dioxide which is known as 'greenhouse effect' in the atmosphere is leading to current global warming. The growing number of scooters, motorcycles, cars, buses and trucks which run on fossil fuel (petrol and diesel) is a major cause of air pollution in cities and along highways.

irregular periods of famine. Agriculturists have no income in these bad years, and as they have no steady income, they have a constant fear of droughts. India has 'Drought Prone Areas Development Programs', which are used in such areas to buffer the effects of droughts. Under these schemes, people are given wages in bad years to build roads, minor irrigation works and plantation programs.

Drought has been a major problem in our country especially in arid regions. It is an unpredictable climatic condition and occurs due to the failure of one or more monsoons. It varies in frequency in different parts of our country.

While it is not feasible to prevent the failure of the monsoon, good environmental management can reduce its ill effects. The scarcity of water during drought years affects homes, agriculture and industry. It also leads to food shortages and malnutrition which especially affects children.

Several measures can be taken to minimize the serious impacts of a drought. However, this must be done as a preventive measure so that if the monsoons fail, the impact on local people's lives is minimised.

In years when the monsoon is adequate, we use up the good supply of water without trying to conserve it and use the water judiciously. Thus during a year when the rains are poor, there is no water even for drinking in the drought area.

One of the factors that worsens the effect of drought is deforestation. Once hill slopes are denuded of forest cover the rainwater rushes down the rivers and is lost. Forest cover permits water to be held in the area permitting it to seep into the ground. This charges the underground stores of water in natural aquifers. This can be used in drought years if the stores have been filled during a good monsoon. If water from the underground stores is overused, the

water table drops and vegetation suffers. This soil and water management and afforestation are long-term measures that reduce the impact of droughts.

Water for Agriculture and Power Generation: India's increasing demand for water for intensive irrigated agriculture, for generating electricity, and for consumption in urban and industrial centers, has been met by creating large dams. Irrigated areas increased from 40 million ha. in 1900 to 100 million ha. in 1950 and to 271 million ha. by 1998. Dams support 30 to 40% of this area.

Although dams ensure a year round supply of water for domestic use, provide extra water for agriculture, industry, hydropower generation, they have several serious environmental problems. They alter river flows, change nature's flood control mechanisms such as wetlands and flood plains, and destroy the lives of local people and the habitats of wild plant and animal species.

Irrigation to support cash crops like sugarcane produces an unequal distribution of water. Large landholders on the canals get the lion's share of water, while poor, small farmers get less and are seriously affected.

Sustainable water management: 'Save water' campaigns are essential to make people everywhere aware of the dangers of water scarcity. A number of measures need to be taken for the better management of the world's water resources. These include measures such as:

- Building several small reservoirs instead of few mega projects.
- Develop small catchment dams and protect wetlands.

- Soil management, micro catchment development and afforestation permits recharging of underground aquifers thus reducing the need for large dams.
- Treating and recycling municipal waste water for agricultural use.
- Preventing leakages from dams and canals.
- Preventing loss in Municipal pipes.
- Effective rain water harvesting in urban environments.
- Water conservation measures in agriculture such as using drip irrigation.
- Pricing water at its real value makes people use it more responsibly and efficiently and reduces water wasting.
- In deforested areas where land has been degraded, soil management by bunding along the hill slopes and making 'nala' plots, can help retain moisture and make it possible to re-vegetate degraded areas.

Managing a river system is best done by leaving its course as undisturbed as possible. Dams and canals lead to major floods in the monsoon and the drainage of wetlands seriously affects areas that get flooded when there is high rainfall.

Dams: Today there are more than 45,000 large dams around the world, which play an important role in communities and economies that harness these water resources for their economic development. Current estimates suggest some 30-40% of irrigated land worldwide relies on dams. Hydropower, another contender for the use of stored water, currently supplies 19% of the world's total electric power supply and is used in over 150 countries. The world's two most populous countries – China and India –

have built around 57% of the world's large dams.

Dams problems

- Fragmentation and physical transformation of rivers.
- Serious impacts on riverine ecosystems.
- Social consequences of large dams due to displacement of people.
- Water logging and salinisation of surrounding lands.
- Dislodging animal populations, damaging their habitat and cutting off their migration routes.
- Fishing and trade by boat disrupted.
- The emission of green house gases from reservoirs due to rotting vegetation and carbon inflows from the catchment is a recently identified impact.

Large dams have had serious impacts on the lives, livelihoods, cultures and spiritual existence of indigenous and tribal peoples. They have suffered disproportionately from the negative impacts of dams and often been excluded from sharing the benefits. In India, of the 16 to 18 million people displaced by dams, 40 to 50% were tribal people, who account for only 8% of our nation's one billion people.

Conflicts over dams have heightened in the last two decades because of their social and environmental impacts and failure to achieve targets for sticking to their costs as well as achieving promised benefits. Recent examples show how failure to provide a transparent process that includes effective participation of local people has prevented affected people from playing an

- (3) Development: Work of preparing access to the deposit so that the minerals can be extracted from it.
- (4) Exploitation: Extracting the minerals from the mines.

In the past, mineral deposits were discovered by prospectors in areas where mineral deposits in the form of veins were exposed on the surface. Today, however, prospecting and exploration is done by teams of geologists, mining engineers, geophysicists, and geochemists who work together to discover new deposits. Modern prospecting methods include the use of sophisticated instruments like GIS to survey and study the geology of the area.

The method of mining has to be determined depending on whether the ore or mineral deposit is nearer the surface or deep within the earth. The topography of the region and the physical nature of the ore deposit is studied.

Mines are of two types – surface (open cut or strip mines) or deep or shaft mines. Coal, metals and non-metaliferous minerals are all mined differently depending on the above criteria. The method chosen for mining will largely depend on how maximum yield may be obtained under existing conditions at a minimum cost, with the least danger to the mining personnel.

Most minerals need to be processed before they become usable. Thus 'technology' is dependent on both the presence of resources and the energy necessary to make them 'usable'.

Mine safety: Mining is a hazardous occupation, and the safety of mine workers is an important environmental consideration of the industry. Surface mining is less hazardous than underground mining. Metal mining is less hazardous than coal mining. In all underground mines, rock and roof falls, flooding, and inad-

CASE STUDY

Sariska Tiger Reserve, Rajasthan

The Forest Department has leased land for mining in the Sariska Tiger Reserve area by denotifying forest areas. The local people have fought against the mining lobby, and have filed a Public Interest Litigation in the Supreme Court in 1991. Rajendra Singh, secretary of TBS, points out that as many as 70 mines operate in close proximity to the forest.

equated ventilation are the greatest hazards. Large explosions have occurred in coal mines, killing many miners. More miners have suffered from disasters due to the use of explosives in metal mines.

Mining poses several long-term occupational hazards to the miners. Dust produced during mining operations is injurious to health and causes a lung disease known as black lung, or pneumoconiosis. Fumes generated by incomplete dynamite explosions are extremely poisonous. Methane gas, emanating from coal strata, is hazardous to health although not poisonous in the concentrations usually encountered in mine air. Radiation is a hazard in uranium mines.

Environmental problems: Mining operations are considered one of the main sources of environmental degradation. The extraction of all these products from the lithosphere has a variety of side effects. Depletion of available land due to mining, waste from industries, conversion of land to industry and pollution of land, water and air by industrial wastes, are environmental side effects of the use of these non-renewable resources. Public awareness of this

Types of energy: There are three main types of energy; those classified as **non-renewable**; those that are said to be **renewable**; and **nuclear energy**, which uses such small quantities of raw material (uranium) that supplies are to all effect, limitless. However, this classification is inaccurate because several of the renewable sources, if not used 'sustainably', can be depleted more quickly than they can be renewed.

Non renewable energy

To produce electricity from non-renewable resources the material must be ignited. The fuel is placed in a well contained area and set on fire. The heat generated turns water to steam, which moves through pipes, to turn the blades of a turbine. This converts magnetism into electricity, which we use in various appliances.

Non-Renewable Energy Sources: These consist of the mineral based hydrocarbon fuels coal, oil and natural gas, that were formed from ancient prehistoric forests. These are called 'fossil fuels' because they are formed after plant life is fossilized. At the present rate of extraction there is enough coal for a long time to come. Oil and gas resources however are likely to be used up within the next 50 years. When these fuels are burnt, they produce waste products that are released into the atmosphere as gases such as carbon dioxide, oxides of sulphur, nitrogen, and carbon monoxide, all causes of air pollution. These have led to lung problems in an enormous number of people all over the world, and have also affected buildings like the Taj Mahal and killed many forests and lakes due to acid rain. Many of these gases also act like a green house letting sunlight in and trapping the heat inside. This is leading to global warming, a raise in global temperature, increased drought in some areas, floods in other regions, the melting of icecaps, and a rise in sea levels, which is slowly submerging coastal belts all over the world.

Natural Resources

Warming the seas also leads to the death of sensitive organisms such as coral.

Oil and its environmental impacts: India's oil reserves which are being used at present lie off the coast of Mumbai and in Assam. Most of our natural gas is linked to oil and, because there is no distribution system, it is just burnt off. This wastes nearly 40% of available gas. The processes of oil and natural gas drilling, processing, transport and utilisation have serious environmental consequences, such as leaks in which air and water are polluted and accidental fires that may go on burning for days or weeks before the fire can be controlled. During refining oil, solid waste such as salts and grease are produced which also damage the environment. Oil slicks are caused at sea from offshore oil wells, cleaning of oil tankers and due to ship wrecks. The most well-known disaster occurred when the Exxon

Valdez sank in 1989 and birds, sea otters, seals, fish and other marine life along the coast of Alaska was seriously affected.

Oil powered vehicles emit carbon dioxide, sulphur dioxide, nitrous oxide, carbon monoxide and particulate matter which is a major cause of air pollution especially in cities with heavy traffic density. Leaded petrol, leads to neuro damage and reduces attention spans. Running petrol vehicles with unleaded fuel has been achieved by adding catalytic converters on all the new cars, but unleaded fuel contains benzene and butadiene which are known to be carcinogenic compounds. Delhi, which used to have serious



CASE STUDY

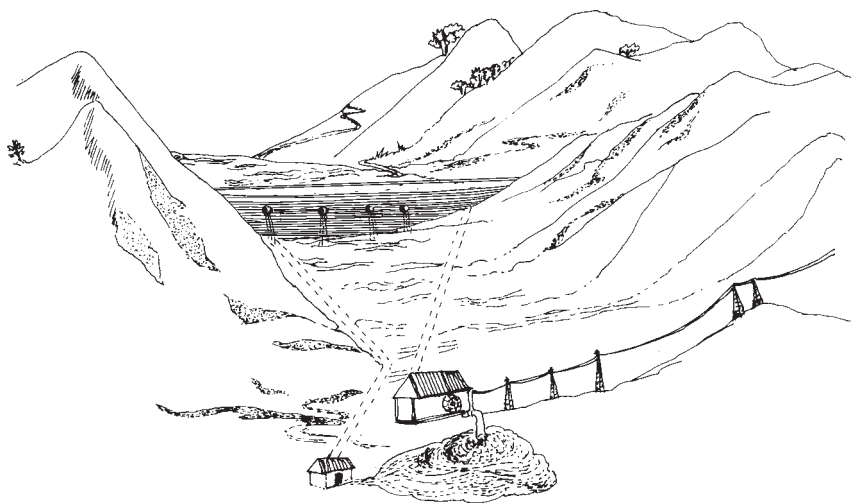
Nearly 50% of the world's population is dependent on fuel wood as a source of energy. This is obvious in our own country, which has lost a large proportion of its forest cover as our population expands and burns enormous amounts of wood. Rural women, and even women from the lower economic strata in towns, still have to spend a large part of their lives collecting fuel wood. To overcome this, various types of fuel-efficient stoves ('chulas') can burn wood extremely slowly and do not waste the heat, and also produce less smoke and ash than normal 'chulas'. There have also been several efforts to grow fuelwood by involving local people in these efforts. Examples include Social Forestry, Farm Forestry and Joint Forestry Management.

CASE STUDY

In 1882, the first Hydroelectric power dam was built in Appleton, Wisconsin. In India the first hydroelectric power dams were built in the late 1800s and early 1900s by the Tatas in the Western Ghats of Maharashtra. Jamshedjee Tata, a great visionary who developed industry in India in the 1800s, wished to have a clean source of energy to run cotton and textile mills in Bombay as he found people were getting respiratory infections due to coal driven mills. He thus asked the British Government to permit him to develop dams in the Western Ghats to generate electricity. The four dams are the Andhra, Shirowata, Valvan and Mulshi hydel dams. An important feature of the Tata power projects is that they use the high rainfall in the hills as storage areas. While the rivers flowing eastwards from the Western Ghats are dammed in the foothills near the Deccan plateau, the water is tunneled through the west of the Ghats to drop several hundred meters to the coastal belt. Large turbines in the power plants generate electricity for Mumbai and its giant industrial belt.

Hydroelectric Power

This uses water flowing down a natural gradient to turn turbines to generate electricity known as 'hydroelectric power' by constructing dams across rivers. Between 1950 and 1970, Hydropower generation worldwide increased



seven times. The long life of hydropower plants, the renewable nature of the energy source, very low operating and maintenance costs, and absence of inflationary pressures as in fossil fuels, are some of its advantages.

Solar heating for homes: Modern housing that uses air conditioning and/ or heating are extremely energy dependant. A passive solar home or building is designed to collect the sun's heat through large, south-facing glass windows. In solar heated buildings, *sunspaces* are built on the south side of the structure which act as large heat absorbers. The floors of sunspaces are usually made of tiles or bricks that absorb heat throughout the day, then release heat at night when its cold.

In energy efficient architecture the sun, water and wind are used to heat a building when the weather is cold and to cool it in summer. This is based on design and building material. Thick walls of stone or mud were used in traditional architecture as an insulator. Small doors and windows kept direct sunlight and heat out. Deeply set glass windows in colonial homes, on which direct sunlight could not reach, permitted the glass from creating a green house effect. Verandahs also served a similar purpose.

Traditional bungalows had high roofs and ventilators that permitted hot air to rise and leave the room. Cross ventilation where wind can drive the air in and out of the room keeps it cool. Large overhangs over windows prevent the glass from heating the room inside. Double walls are used to prevent heating. Shady trees around the house help reduce temperature.

Solar water heating: Most solar water-heating systems have two main parts: the solar *collector* and the *storage tank*. The solar energy collector heats the water, which then flows to a well insulated storage tank.

A common type of collector is the *flat-plate collector*, a rectangular box with a transparent cover that faces the sun, usually mounted on the roof. Small tubes run through the box, carrying the water or other fluid, such as antifreeze, to be heated. The tubes are mounted on a metal *absorber plate*, which is painted black to ab-

sorb the sun's heat. The back and sides of the box are insulated to hold in the heat. Heat builds up in the collector, and as the fluid passes through the tubes, it too heats up.

Solar water-heating systems cannot heat water when the sun is not shining. Thus homes must also have a conventional backup system. About 80% of homes in Israel have solar hot water heaters.

Solar cookers: The heat produced by the sun can be directly used for cooking using solar cookers. A solar cooker is a metal box which is black on the inside to absorb and retain heat. The lid has a reflective surface to reflect the heat from the sun into the box. The box contains black vessels in which the food to be cooked is placed.

India has the world's largest solar cooker program and an estimated 2 lakh families that use solar cookers. Although solar cookers reduce the need for fuelwood and pollution from smoky wood fires, they have not caught on well in rural areas as they are not suitable to traditional cooking practices. However, they have great potential if marketed well.

Other Solar-Powered Devices: Solar desalination systems (for converting saline or brackish water into pure distilled water) have been developed. In future, they should become important alternatives for man's future economic growth in areas where fresh water is not available.

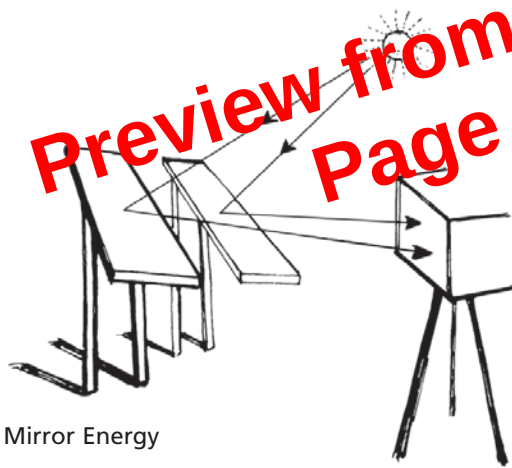
Photovoltaic energy: The solar technology which has the greatest potential for use throughout the world is that of solar photo voltaic cells which directly produce electricity from sunlight using *photovoltaic (PV)* (also called *solar*) cells.

Solar cells use the sun's light, not its heat, to make electricity. PV cells require little maintenance, have no moving parts, and essentially no environmental impact. They work cleanly,

though the second most abundant element in the earth's crust, has to be mined. Mining creates environmental problems. PV systems also of course only work when the sun is shining, and thus need batteries to store the electricity.

Solar thermal electric power: Solar radiation can produce high temperatures, which can generate electricity. Areas with low cloud levels of cover with little scattered radiation as in the desert are considered most suitable sites. According to a UNDP assessment, STE is about 20 years behind the wind energy market exploitation, but is expected to grow rapidly in the near future.

Mirror energy: During the 1980s, a major solar thermal electrical generation unit was built in California, containing 700 parabolic mirrors, each with 24 reflectors, 1.5 meters in diameter, which focused the sun's energy to produce steam to generate electricity.



Mirror Energy

Solar thermal systems change sunlight into electricity, by focusing sunlight to boil water to make steam.

Biomass energy: When a log is burned we are using *biomass energy*. Because plants and trees depend on sunlight to grow, biomass energy is a form of stored solar energy. Although wood is the largest source of biomass energy, we also use agricultural waste, sugarcane wastes, and other farm byproducts to make energy.

There are three ways to use biomass. It can be burned to produce heat and electricity, changed to a gas-like fuel such as methane, or changed to a liquid fuel. Liquid fuels, also called *biofuels*, include two forms of alcohol: *ethanol* and *methanol*. Because biomass can be changed directly into liquid fuel, it could someday supply much of our transportation fuel needs for cars, trucks, buses, airplanes and trains with diesel fuel replaced by '*biodiesel*' made from vegetable oils. In the United States, this fuel is now being produced from soybean oil. Researchers are also developing algae that produce oils, which can be converted to biodiesel and new ways have been found to produce ethanol from grasses, tree bark, sawdust, paper, and farming wastes.

Organic municipal solid waste includes paper, food wastes, and other organic non-fossil-fuel derived materials such as textiles, natural rubber, and leather that are found in the waste of urban areas. Currently, in the US, approximately 31% of organic waste is recovered from municipal solid waste via recycling and composting programs, 62% is deposited in landfills, and 7% is incinerated. Waste material can be converted into electricity by combustion boilers or steam turbines.

Note that like any fuel, biomass creates some pollutants, including carbon dioxide, when burned or converted into energy. In terms of air pollutants, biomass generate less relative to fossil fuels. Biomass is naturally low in sulphur and therefore, when burned, generates low sulphur dioxide emissions. However, if burned in the open air, some biomass feedstocks would emit relatively high levels of nitrous oxides (given the

high nitrogen content of plant material), carbon monoxide, and particulates.

Biogas: Biogas is produced from plant material and animal waste, garbage, waste from households and some types of industrial wastes, such as fish processing, dairies, and sewage treatment plants. It is a mixture of gases which includes methane, carbon dioxide, hydrogen sulphide and water vapour. In this mixture, methane burns easily. With a ton of food waste, one can produce 85 Cu. M of biogas. Once used, the residue is used as an agricultural fertilizer.

Denmark produces a large quantity of biogas from waste and produces 15,000 megawatts of electricity from 15 farmers' cooperatives. London has a plant which makes 30 megawatts of electricity a year from 420,000 tons of municipal waste which gives power to 50,000 families. In Germany, 25% of landfills for garbage produce power from biogas. Japan uses 85% of its waste and France about 50%.

Biogas plants have become increasingly popular in India in the rural sector. The biogas plants use cowdung, which is converted into a gas which is used as a fuel. It is also used for running dual fuel engines. The reduction in kitchen smoke by using biogas has reduced lung conditions in thousands of homes.

The fibrous waste of the sugar industry is the world's largest potential source of biomass energy. Ethanol produced from sugarcane molasses is a good automobile fuel and is now used in a third of the vehicles in Brazil.

The National Project on Biogas Development (NPBD), and Community/ Institutional Biogas Plant Program promote various biogas projects. By 1996 there were already 2.18 million families in India that used biogas. However China has 20 million households using biogas!

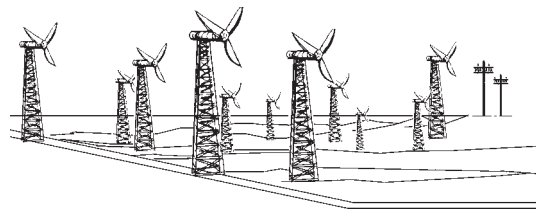
Activity 5:

What you may throw out in your garbage today could be used as fuel for someone else. Municipal solid waste has the potential to be a large energy source. Garbage is an inexpensive energy resource. Unlike most other energy resources, someone will collect garbage, deliver it to the power plant, and even pay to get rid of it. This helps cover the cost of turning garbage into energy. Garbage is also a unique resource because we all contribute to it.

Keep a record of all the garbage that you and our family produce in a day. What proportion of it is in the form of biomass? Weigh this.

How long would it take you to gather enough waste biomass to make a tankful (0.85 cu.m.) of biogas? (Remember one ton of biomass produces 85 cu.m. of biogas)

Wind Power: Wind was the earliest energy source used for transportation by sailing ships. Some 2000 years ago, windmills were developed



in China, Afghanistan and Persia to draw water for irrigation and grinding grain. Most of the early work on generating electricity from wind was carried out in Denmark, at the end of the last century. Today, Denmark and California have large wind turbine cooperatives which sell electricity to the government grid. In Tamil Nadu, there are large wind farms producing 850 megawatts of electricity. At present, India is the third largest wind energy producer in the world.

perhaps reached a critical flash point, at which economic 'development' affects the lives of people more adversely than the benefits it provides.

What can you do to save electricity?

- Turn off lights and fans as soon as you leave the room.
- Use tube lights and energy efficient bulbs that save energy rather than bulbs. A 40-watt tube light gives as much light as a 100 watt bulb.
- Keep the bulbs and tubes clean. Dust on tubes and bulbs decreases lighting levels by 20 to 30 percent.
- Switch off the television or radio as soon as the program of interest is over.
- A pressure cooker can save up to 75 percent of energy required for cooking. It is also faster.
- Keeping the vessel covered with a lid during cooking, helps to cook faster, thus saving energy.

tional levels must be based on the ability to distribute benefits of natural resources by sharing them more equally among the countries as well as among communities within countries such as our own. It is at the local level where people subsist by the sale of locally collected resources, that the disparity is greatest. 'Development' has not reached them and they are often unjustly accused of 'exploiting' natural resources. They must be adequately compensated for the removal of the sources to distant regions and thus develop a greater stake in protecting natural resources.

There are several principles that each of us can adopt to bring about sustainable lifestyles. This primarily comes from caring for our Mother Earth in all respects. A love and respect for Nature is the greatest sentiment that helps bring about a feeling for looking at how we use natural resources in a new and better way. Think of the beauty of a wilderness, a natural forest in all its magnificence, the expanse of a green landscape, the clean water of a lake that supports so much life, the crystal clear water of a hill stream, or the magnificent power of the oceans, and we cannot help but support the conservation of nature's wealth. If we respect this we cannot commit acts that will deplete our life supporting systems.

2.4 EQUITABLE USE OF RESOURCES FOR SUSTAINABLE LIFESTYLES

Reduction of the unsustainable and unequal use of resources, and control of our population growth are essential for the survival of our nation and indeed of human kind everywhere. Our environment provides us with a variety of goods and services necessary for our day-to-day lives, but the soil, water, climate and solar energy which form the 'abiotic' support that we derive from nature, are in themselves not distributed evenly throughout the world or within countries. A new economic order at the global and at na-

Natural Resources

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3.1 CONCEPT OF AN ECOSYSTEM

An 'Ecosystem' is a region with a specific and recognizable landscape form such as forest, grassland, desert, wetland or coastal area. The nature of the ecosystem is based on its geographical features such as hills, mountains, plains, rivers, lakes, coastal areas or islands. It is also controlled by climatic conditions such as the amount of sunlight, the temperature and the rainfall in the region. The geographical, climatic and soil characteristics form its non-living (abiotic) component. These features create conditions that support a community of plants and animals that evolution has produced to live in these specific conditions. The living part of the ecosystem is referred to as its biotic component.

Ecosystems are divided into terrestrial or land-based ecosystems, and aquatic ecosystems in water. These form the two major habitat conditions for the Earth's living organisms.

All the living organisms in an area live in communities of plants and animals. They interact with their non-living environment, and with each other at different points in time for a large number of reasons. Life can exist only in a small proportion of the earth's land, water and air atmosphere. At a *global level* the thin skin of the earth on the land, the sea and the air, forms the biosphere.

At a *sub-global level*, this is divided into **biogeographical realms**, eg. Eurasia called the palaeartic realm; South and South-East Asia (of which India forms a major part) is the Oriental realm; North America is the Nearctic realm; South America forms the Neotropical realm; Africa the Ethiopian realm; and Australia the Australian realm.

At a national or state level, this forms **biogeographic regions**. There are several distinctive geographical regions in India- the Himalayas, the Gangetic Plains, the Highlands of Central India,

the Western and Eastern Ghats, the semi-arid desert in the West, the Deccan Plateau, the Coastal Belts, and the Andaman and Nicobar Islands. These geographically distinctive areas have plants and animals that have been adapted to live in each of these regions.

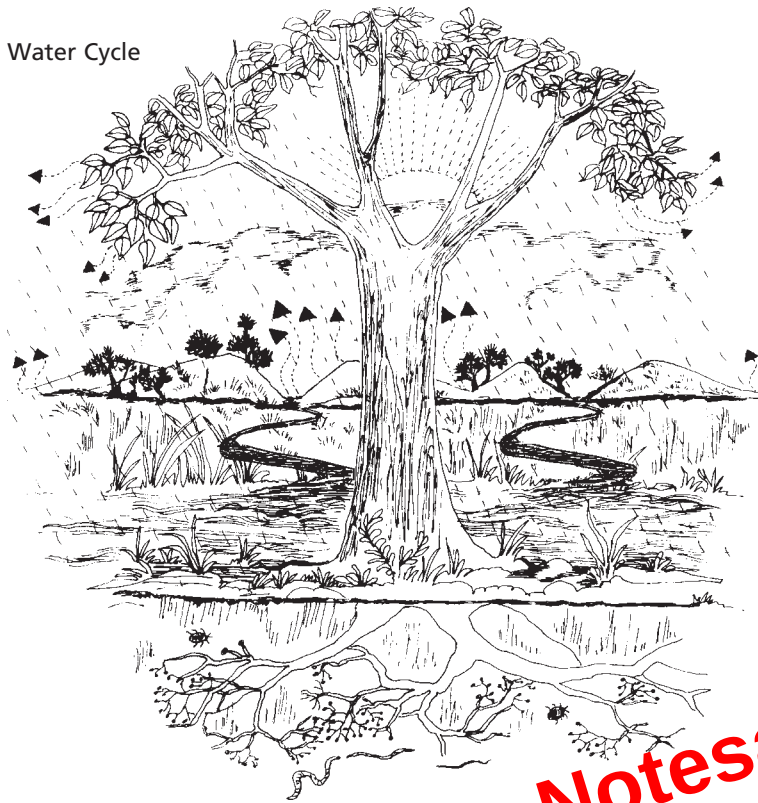
At an even more local level, each area has several structurally and functionally identifiable **ecosystems** such as different types of forests, grasslands, river catchments, mangrove swamps in deltas, seashores, islands, etc. to give only a few examples. Here too each of these forms a habitat for specific plants and animals.

Ecosystems have been formed on land and in the sea by evolution that has created species to live together in a specific region. Thus ecosystems have both non-living and living components that are typical to an area giving it its own special characteristics that are easily observed.

Definition: The living community of plants and animals in any area together with the non-living components of the environment such as soil, air and water constitute the ecosystem.

Some ecosystems are fairly robust and are less affected by a certain level of human disturbance. Others are highly fragile and are quickly destroyed by human activities. Mountain ecosystems are extremely fragile as degradation of forest cover leads to severe erosion of soil and changes in river courses. Island ecosystems are easily affected by any form of human activity which can lead to the rapid extinction of several of their unique species of plants and animals. Evergreen forests and coral reefs are also examples of species rich fragile ecosystems which must be protected against a variety of human activities that lead to their degradation. River and wetland ecosystems can be seriously affected by pollution and changes in surrounding landuse.

Water Cycle

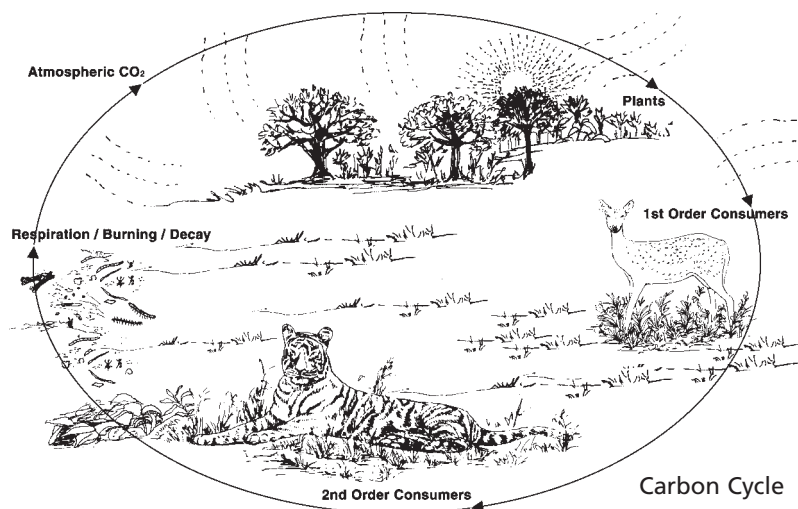


to the atmosphere. As it is lighter than air, water vapour rises and forms clouds. Winds blow the clouds for long distances and when the clouds rise higher, the vapour condenses and changes into droplets, which fall on the land as rain. Though this is an endless cycle on which life depends, man's activities are making drastic changes in the atmosphere through pollution which is altering rainfall patterns. This is leading to prolonged drought periods extending over years in countries such as Africa, while causing floods in countries such as the US. El Nino storms due to these effects have devastated many places in the last few years.

Ecosystems

3.4.2 The Carbon cycle

The carbon, which occurs in organic compounds, is included in both the abiotic and biotic parts of the ecosystem. Carbon is a building block of both plant and animal tissues. In the atmosphere, carbon occurs as carbon dioxide (CO_2). In the presence of sunlight, plants take up carbon dioxide from the atmosphere through their leaves. The plants combine carbon dioxide with water, which is absorbed by their roots from the soil. In the presence of sunlight they are able to form carbohydrates that contain carbon. This process is known as photosynthesis. Plants use this complex mechanism for their growth and development. In this process, plants release oxygen into the atmosphere on which animals depend for their respiration. Plants therefore help in regulating and monitoring the percentage of Oxygen and Carbon dioxide in the earth's atmosphere. All of mankind thus depends on

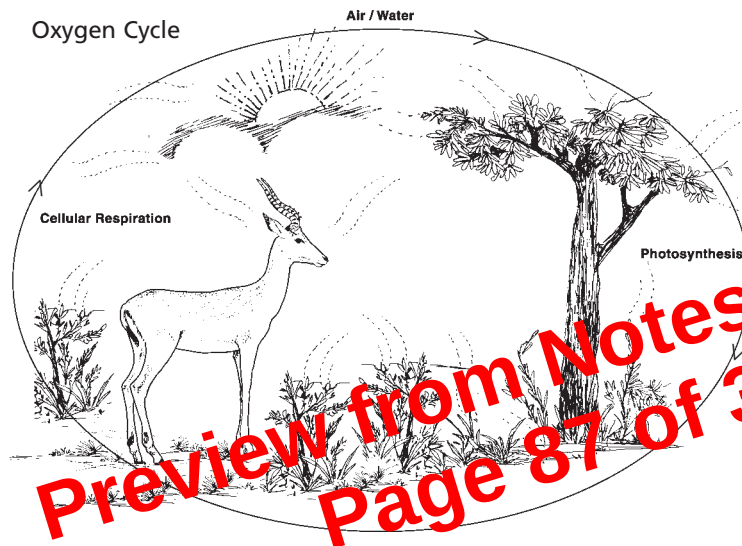


the oxygen generated through this cycle. It also keeps the CO_2 at acceptable levels.

Herbivorous animals feed on plant material, which is used by them for energy and for their growth. Both plants and animals release carbon dioxide during respiration. They also return fixed carbon to the soil in the waste they excrete. When plants and animals die they return their carbon to the soil. These processes complete the carbon cycle.

3.4.4 The Nitrogen Cycle

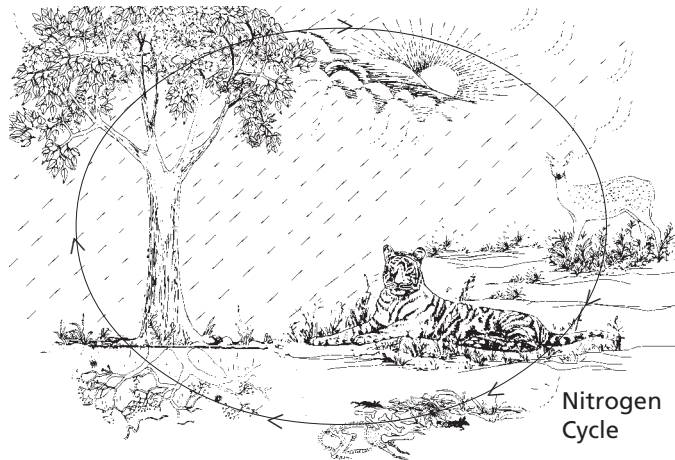
Carnivorous animals feed on herbivorous animals that live on plants. When animals defecate, this waste material is broken down by worms and insects mostly beetles and ants. These small 'soil animals' break the waste material into smaller bits on which microscopic bacteria and fungi can act. This material is thus broken down further into nutrients that plants can absorb and use for their growth. Thus nutrients are recycled back from animals to plants. Similarly the bodies of dead animals are also broken down into nutrients that are used by the plants for their growth. Thus the nitrogen cycle on which life is dependent is completed.



Nitrogen fixing bacteria and fungi in soil gives this important element to plants, which absorb it as nitrates. The nitrates are a part of the plant's metabolism, which help in forming new plant proteins. This is used by animals that feed on the plants. The nitrogen is then transferred to carnivorous animals when they feed on the herbivores. Thus our own lives are

3.4.3 The Oxygen Cycle

Oxygen is taken up by plants and animals from the air during respiration. The plants return oxygen to the atmosphere during photosynthesis. This links the Oxygen Cycle to the Carbon Cycle. Deforestation is likely to gradually reduce the oxygen levels in our atmosphere. Thus plant life plays an important role in our lives which we frequently do not appreciate. This is an important reason to participate in afforestation programs.





Coniferous forest



Broadleaved forest

have cones instead of seeds and are called gymnosperms.

Broadleaved forests have several types, such as evergreen forests, deciduous forests, thorn forests, and mangrove forests. Broadleaved forests have large leaves of various shapes.

Evergreen forests grow in the high rainfall areas of the Western Ghats, North Eastern India and the Andaman and Nicobar Islands. These forests grow in areas where the monsoon lasts for sev-

eral months. Some even get two monsoons, such as in Southern India. Evergreen plants shed a few of their leaves throughout the year. There is no dry leafless phase as in a deciduous forest. An evergreen forest thus looks green throughout the year. The trees overlap with each other to form a continuous canopy. Thus very little light penetrates down to the forest floor. Only a few shade loving plants can grow in the ground layer in areas where some light filters down from the closed canopy. The forest is rich in orchids and ferns. The barks of the trees are covered in moss. The forest abounds in animal life and is most rich in insect life.



Evergreen forest

Semiarid grassland



The **Semi-arid plains of Western India, Central India and the Deccan** are covered by grassland tracts with patches of thorn forest. Several mammals such as the wolf, the blackbuck, the chinkara, and birds such as the bustards and floricans are adapted to these arid conditions. The Scrublands of the Deccan Plateau are covered with seasonal grasses and herbs on which its fauna is dependent. It is teeming with insect life on which the insectivorous birds feed.

Shola grassland



The **Shola grasslands** consist of patches on hillslopes along with the Shola forests on the Western Ghats, Nilgiri and Annamalai ranges. This forms a patchwork of grassland on the slopes and forest habitats along the streams and lowlying areas.

Grasslands are not restricted only to low rainfall areas. Certain grassland types form when clearings are made in different forest types. Some are located on the higher steep hill slopes with

patches of forest that occur along the streams and in depressions. The grasslands are related to repeated fires that do not permit the forest to grow.

The grasses are the major producers of biomass in these regions. Each grassland ecosystem has a wide variety of species of grasses and herbs. Some grass and herb species are more sensitive to excessive grazing and are suppressed if the area is over grazed. Others are destroyed by repeated fires and cannot regenerate. Thus over-used or frequently burnt grasslands are degraded and are poor in plant species diversity.

How are grasslands used?

Grasslands are the grazing areas of many rural communities. Farmers who keep cattle or goats, as well as shepherds who keep sheep, are highly dependent on grasslands. Domestic animals are grazed in the 'common' land of the village. Fodder is collected and stored to feed cattle when there is no grass left for them to graze in summer. Grass is also used to thatch houses and farm sheds. The thorny bushes and branches of the few trees that are seen in grasslands are used as a major source of fuelwood.

Overgrazing by huge herds of domestic livestock has degraded many grasslands. Grasslands have diverse species of insects that pollinate crops. There are also predators of these insects such as the small mammals like shrews, reptiles like lizards, birds of prey, and amphibia such as frogs and toads. All these carnivorous animals help to control insect pests in adjoining agricultural lands.

What are the threats to grassland ecosystems?

In many areas grasslands have been used for centuries by pastoral communities. Overutilization and changes in landuse of the

'common grazing lands' of rural communities has led to their degradation. The grassland cover in the country in terms of permanent pastures now covers only 3.7 percent of land. A major threat to natural grasslands is the conversion of grasslands into irrigated farmlands. In the Deccan, grasslands have been altered to irrigated farms and are now mainly used to grow sugarcane. After continuous irrigation such land becomes saline and useless in a few years. More recently many of these residual grassland tracts have been converted into industrial areas. This provides short-term economic gains but results in long-term economic and ecological losses.

Grasslands have a limited ability to support domestic animals and wildlife. Increasing this pressure by increasing the number of domestic animals reduces the 'naturalness' of the grassland ecosystem leading to its degradation.

Most grassland ecosystems are highly modified by human activities. Cattle, sheep and goat grazing, and lighting repeated fires affects grasslands adversely. Changing the grasslands to other forms of land use such as agriculture, tree plantations and industrialisation forms a serious threat to this highly productive ecosystem. Thus some of the grassland patches which are in a less disturbed state and have retained their special plants and animals need to be urgently protected.

Degradation of grasslands due to over grazing by cattle, sheep and goats occurs if more than a critical number of domestic animals are present in the grasslands. When animals overgraze the area, the grasses are converted into flat stubs with very little green matter. Degraded grasslands have fewer grass species as the nutritious species are entirely used up by the large number of domestic animals. They are thus unable to regenerate.

When fires are lit in the grasslands in summer, the burnt grass gets a fresh flush of small green

shoots which the domestic animals graze on. If this is done too frequently the grasslands begin to deteriorate. Finally grasslands become bare, the soil is solidly compacted by trampling, or is washed away during the monsoon by rain and whipped into dust storms during the hot dry summer. The land is degraded, as there is no grass to hold the soil in place. It becomes a wasteland.

Why are our grassland species vanishing?

Most people feel that it is only our forests and its wildlife that is disappearing. However, other natural ecosystems such as grasslands are disappearing even more rapidly.

Many of the grassland species have disappeared from several parts of India in which they were found 50 or 60 years ago. The cheetah is extinct in India. The wolf is now highly threatened. Blackbuck and chinkara are poached for meat. Birds such as the beautiful Great Indian Bustards are vanishing. Unless grassland species are protected they will disappear from their shrinking habitat, as natural and undisturbed grasslands are left in very few locations. If these animals and birds are killed or their habitat is reduced further, their extinction will rapidly follow.

What if our grasslands disappear?

If our grasslands are lost we will lose a highly specialised ecosystem in which plants and animals have been adapted to these habitat conditions over millions of years. Local people will not be able to support their livestock herds.

The extinction of species is a great loss to mankind. The genes of wild grasses are extremely useful for developing new crop varieties. New medicines could well be discovered from wild grassland plants. It is possible that genes from wild herbivores such as wild sheep, goats and antelopes may be used for developing new strains of domestic animals.

these are low-lying areas near the sea, they get converted to salt marshes during the monsoons. During this period they attract an enormous number of aquatic birds such as ducks, geese, cranes, storks, etc. The Great Rann is famous, as it is the only known breeding colony of the Greater and Lesser Flamingos in our country. The Little Rann of Kutch is the only home of the wild ass in India.

Desert and semi arid regions have a number of highly specialized insects and reptiles. The rare animals include the Indian wolf, desert cat, desert fox and birds such as the Great Indian Bustard and the Florican. Some of the commoner birds include partridges, quails and sandgrouse.

How are desert and semi-arid ecosystems used?

Areas of scanty vegetation with semi-arid scrubland have been used for camel, cattle and goat grazing in Rajasthan and Gujarat, and for sheep grazing in the Deccan Plateau.

Areas that have a little moisture, such as along the watercourses, have been used for growing crops such as jowar, and cotton. The natural grasses and local varieties of crops have adapted to growing at very low moisture levels. These can be used for genetic engineering and developing arid land crops for the future.

What are the threats to desert ecosystems?

Several types of development strategies as well as human population growth have begun to affect the natural ecosystem of the desert and semi arid land. Conversion of these lands through extensive irrigation systems has changed several of the natural characteristics of this region. The canal water evaporates rapidly bringing the salts to the surface. The region becomes highly unproductive as it becomes saline. Pulling excessive groundwater from tube

wells lowers the water table creating an even drier environment. Thus human activities destroy the naturalness of this unique ecosystem. The special species that evolved here over millions of years may soon become extinct.

How can desert ecosystems be conserved?

Desert ecosystems are extremely sensitive. Their ecological balance that forms a habitat for their plants and animals is easily disturbed. Desert people have traditionally protected their meagre water resources. The Bishnois in Rajasthan are known to have protected their Khejdi trees and the blackbuck antelope for several generations. The tradition began when the ruler of their region ordered his army to cut down trees for his own use. Several Bishnois were said to have been killed while trying to protect their trees.

There is an urgent need to protect residual patches of this ecosystem within National Parks and Wildlife Sanctuaries in desert and semi arid areas. The Indira Gandhi Canal in Rajasthan is destroying this important natural arid ecosystem, and will convert the region into intensive agriculture. In Kutch, areas of the little Rann, which is the only home of the Wild Ass, will be destroyed by the spread of salt works.

Development Projects alter the desert and arid landscape. There is a sharp reduction in the habitat available for its specialised species bringing them to the verge of extinction. We need a sustainable form of development that takes the special needs of the desert into account.

3.7.4 Aquatic ecosystems

The aquatic ecosystems constitute the marine environments of the seas and the fresh water systems in lakes, rivers, ponds and wetlands. These ecosystems provide human beings with a wealth of natural resources. They provide goods that people collect for food such as fish and

How are aquatic ecosystems used?

Man uses aquatic ecosystems for the clean fresh-water on which his life is completely dependent. We need clean water to drink and for other domestic uses. Water is essential for agriculture. Fisherfolk use the aquatic ecosystems to earn a livelihood. People catch fish and crabs. They also collect edible plants. This is used locally as food or for sale in the market. Over fishing leads to a serious decline in the catch and a long-term loss of income for fisherfolk.

Marshes and wetlands are of great economic importance for people who live on their fish, crustacea, reeds, grasses and other produce.

Modern man impounds water in dams to be able to store it throughout the year. Agriculture and industry are highly dependent on large quantities of water. However this leads to problems for tribal people who have lived there before the dams were built as they are displaced to build large dams. These dams make rich people richer in the farmland and supports people in large urban centres that use enormous quantities of water. The poor tribal folk become even poorer as the natural resources they depend on are taken away as their lands are submerged under the water of the dams.

Dams are built across rivers to generate electricity. A large proportion of this energy is used by urban people, by agriculturists in irrigated farmlands and in enormous quantities for industry. Large dams have serious ill effects on natural river ecosystems. While water from dams used for irrigation has led to economic prosperity in some areas, in semiarid areas that are artificially irrigated the high level of evaporation leads to severe salinisation as salts are brought up into the surface layers of the soil. This makes such lands gradually more and more saline and unproductive.

What are the threats to aquatic ecosystems?

Water pollution occurs from sewage and poorly managed solid waste in urban areas when it enters the aquatic ecosystem of lakes and rivers. Sewage leads to a process called eutrophication, which destroys life in the water as the oxygen content is severely reduced. Fish and crustacea cannot breathe and are killed. A foul odour is produced. Gradually the natural flora and fauna of the aquatic ecosystem is destroyed.

In rural areas the excessive use of fertilisers causes an increase in nutrients, which leads to eutrophication. Pesticides used in adjacent fields pollute water and kills off its aquatic animals. Chemical pollution from industry kills a large number of life forms in adjacent aquatic ecosystems. Contamination by heavy metals and other toxic chemicals affects the health of people who live near these areas as they depend on this water.

CASE STUDY

Threats to wetlands in Assam

Almost 40% of all wetlands in Assam are under threat. A survey conducted by the Assam Remote Sensing Application Center (ARSAC), Guwahati, and the Space Research Center, Ahmedabad, has revealed that 1367 out of 3513 wetlands in Assam are under severe threat due to invasion of aquatic weeds and several developmental activities. The wetlands of Assam form the greatest potential source of income for the State in terms of fisheries and tourism. Though the wetlands of Assam have the capacity of producing 5,000 tones of fish per hectare per year, around 20,000 tones of fish have to be imported to meet local demands. This is primarily due to poor wetland management.

4.1 INTRODUCTION

The great variety of life on earth has provided for man's needs over thousands of years. This diversity of living creatures forms a support system which has been used by each civilization for its growth and development. Those that used this "bounty of nature" carefully and sustainably survived. Those that overused or misused it disintegrated.

Science has attempted to classify and categorize the variability in nature for over a century. This has led to an understanding of its organization into communities of plants and animals. This information has helped in utilizing the earth's biological wealth for the benefit of humanity and has been integral to the process of 'development'. This includes better health care, better crops and the use of these life forms as raw material for industrial growth which has led to a higher standard of living for the developed world. However this has also produced the modern consumerist society, which has had a negative effect on the diversity of biological resources upon which it is based. The diversity of life on earth is so great that if we use it sustainably we can develop new products for biodiversity for many generations. This can only happen if we manage biodiversity as a precious resource and prevent the extinction of species.

Definition:

'Biological diversity' or biodiversity is that part of nature which includes the differences in genes among the individuals of a species, the variety and richness of all the plant and animal species at different scales in space, locally, in a region, in the country and the world, and various types of ecosystems, both terrestrial and aquatic, within a defined area.

What is biodiversity?

Biological diversity deals with the degree of nature's variety in the biosphere. This variety can be observed at three levels; the genetic variability within a species, the variety of species within a community, and the organisation of species in an area into distinctive plant and animal communities constitutes ecosystem diversity.

4.1.1 Genetic diversity

Each member of any animal or plant species differs widely from other individuals in its genetic makeup because of the large number of combinations possible in the genes that give every individual specific characteristics. Thus, for example, each human being is very different from all others. This genetic variability is essential for a healthy breeding population of a species. If the number of breeding individuals is reduced, the dissimilarity of genetic makeup is reduced and inbreeding occurs. Eventually this can lead to the extinction of the species. The diversity in wild species forms the 'gene pool' from which our crops and domestic animals have been developed over thousands of years. Today the variety of nature's bounty is being further harnessed by using wild relatives of crop plants to create new varieties of more productive crops and to breed better domestic animals. Modern biotechnology manipulates genes for developing better types of medicines and a variety of industrial products.

4.1.2 Species diversity

The number of species of plants and animals that are present in a region constitutes its species diversity. This diversity is seen both in natural ecosystems and in agricultural ecosystems. Some areas are more rich in species than others. Natural undisturbed tropical forests have a much greater species richness than plantations developed by the Forest Department for timber

production. A natural forest ecosystem provides a large number of non-wood products that local people depend on such as fruit, fuel wood, fodder, fiber, gum, resin and medicines. Timber plantations do not provide the large variety of goods that are essential for local consumption. In the long-term the economic sustainable returns from non-wood forest products is said to be greater than the returns from felling a forest for its timber. Thus the value of a natural forest, with all its species richness is much greater than a plantation. Modern intensive agricultural ecosystems have a relatively lower diversity of crops than traditional agropastoral farming systems where multiple crops were planted.

At present conservation scientists have been able to identify and categorise about 1.8 million species on earth. However, many new species are being identified, especially in the flowering plants and insects. Areas that are rich in species diversity are called 'hotspots' of diversity. India is among the world's 15 nations that are exceptionally rich in species diversity.

4.1.3 Ecosystem diversity

There are a large variety of different ecosystems on earth which have their own complement of distinctive inter linked species based on the differences in the habitat. Ecosystem diversity can be described for a specific geographical region, or a political entity such as a country, a State or a taluka. Distinctive ecosystems include landscapes such as forests, grasslands, deserts, mountains, etc., as well as aquatic ecosystems such as rivers, lakes, and the sea. Each region also has man-modified areas such as farmland or grazing pastures.

An ecosystem is referred to as 'natural' when it is relatively undisturbed by human activities, or 'modified' when it is changed to other types of uses, such as farmland or urban areas. Ecosystems are most natural in wilderness areas. If natural ecosystems are overused or misused their

productivity eventually decreases and they are then said to be degraded. India is exceptionally rich in its ecosystem diversity.

Evolution and the Genesis of Biodiversity:

The origins of life on earth some three and a half billion years ago are obscure. Life was probably initiated as a product of organic reactions in the Earth's primordial seas. Alternative possibilities such as life beginning in a muddy ooze, or of life having been seeded from outer space have also been suggested. Once life took hold on the planet, it began gradually to diversify. Unicellular unspecialized forms gradually evolved into complex multi-cellular plants and animals. Evolution is related to the ability of living organisms to adapt to changes in their environment. Thus the abiotic changes in nature such as climatic and atmospheric upheavals, repeated glaciations, continental drift and the formation of geographical barriers, segregated different communities of plants and animals and gradually lead to the formation of new species over millions of years.

Most species appear to have a life span extending over several million years. Their adaptability to gradual changes in their habitat, and interactions with newly formed species produce groups of inter linked organisms that continue to evolve together. Food chains, prey-predator relationships, parasitism (complete dependence on another species), commensalism (a partnership beneficial to both species), etc. are important examples. Behavioural patterns of the different species comprising a community of species links them to each other through their breeding biology, feeding patterns, migrations, etc. As ancient species became extinct due to geological upheavals, they left behind empty 'niches' in the habitat that stimulated existing species to fill them through the formation of new species. The Earth's ancient history has seen periods of mega extinctions, which have been followed by periods of formation of new species. Though these repeatedly led to a drastic

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ral causes such as volcanoes, which release ash, dust, sulphur and other gases, or by forest fires that are occasionally naturally caused by lightning. However, unlike pollutants from human activity, naturally occurring pollutants tend to remain in the atmosphere for a short time and do not lead to permanent atmospheric change.

Pollutants that are emitted directly from identifiable sources are produced both by natural events (for example, dust storms and volcanic eruptions) and human activities (emission from vehicles, industries, etc.). These are called *primary pollutants*. There are five primary pollutants that together contribute about 90 percent of the global air pollution. These are carbon oxides (CO and CO₂), nitrogen oxides, sulfur oxides, volatile organic compounds (mostly hydrocarbons) and suspended particulate matter.

Pollutants that are produced in the atmosphere when certain chemical reactions take place among the primary pollutants are called *secondary pollutants*. Eg: sulfuric acid, nitric acid, carbonic acid, etc.

Carbon monoxide is a colourless, odorless and toxic gas produced when organic materials such as natural gas, coal or wood are incompletely burnt. Vehicular exhausts are the single largest source of carbon monoxide. The number of vehicles has been increasing over the years all over the world. Vehicles are also poorly maintained and several have inadequate pollution control equipment resulting in release of greater amounts of carbon monoxide. Carbon monoxide is however not a persistent pollutant. Natural processes can convert carbon monoxide to other compounds that are not harmful. Therefore the air can be cleared of its carbon monoxide if no new carbon monoxide is introduced into the atmosphere.

Sulfur oxides are produced when sulfur containing fossil fuels are burnt.

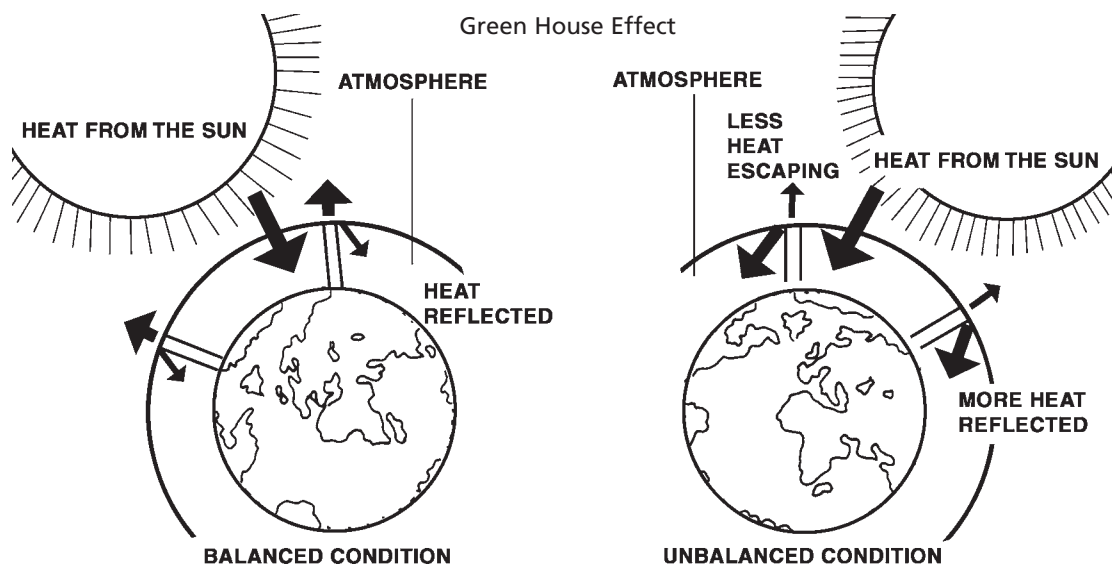
Nitrogen oxides are found in vehicular exhausts. Nitrogen oxides are significant, as they are involved in the production of secondary air pollutants such as ozone.

Hydrocarbons are a group of compounds consisting of carbon and hydrogen atoms. They either evaporate from fuel supplies or are remnants of fuel that did not burn completely. Hydrocarbons are washed out of the air when it rains and run into surface water. They cause an oily film on the surface and do not as such cause a serious issue until they react to form secondary pollutants. Using higher oxygen concentrations in the fuel-air mixture and using valves to prevent the escape of gases, fitting of catalytic converters in automobiles, are some of the modifications that can reduce the release of hydrocarbons into the atmosphere.

Particulates are small pieces of solid material (for example, smoke particles from fires, bits of asbestos, dust particles and ash from industries) dispersed into the atmosphere. The effects of particulates range from not to the carcinogenic (cancer-causing) effects of asbestos, dust particles and ash from industrial plants that are dispersed into the atmosphere. Repeated exposure to particulates can cause them to accumulate in the lungs and interfere with the ability of the lungs to exchange gases.

Lead is a major air pollutant that remains largely unmonitored and is emitted by vehicles. High lead levels have been reported in the ambient air in metropolitan cities. Leaded petrol is the primary source of airborne lead emissions in Indian cities.

Pollutants are also found indoors from infiltration of polluted outside air and from various chemicals used or produced inside buildings. Both indoor and outdoor air pollution are equally harmful.



There could be several adverse effects of global warming.

- With a warmer earth the polar ice caps will melt causing a rise in ocean levels and flooding of coastal areas.
- In countries like Bangladesh or the Maldives this would be catastrophic. If the sea level rises by 3m., Maldives will disappear completely beneath the waves.
- The rise in temperature will bring about a fall in agricultural produce.
- Changes in the distribution of solar energy can bring about changes in habitats. A previously productive agricultural area will suffer severe droughts while rains will fall in locations that were once deserts. This could bring about changes in the species of natural plants, agricultural crops, insects, livestock and micro-organisms.
- In the polar regions temperature rises caused by global warming would have disastrous effects. Vast quantities of meth-

ane are trapped beneath the frozen soil of Alaska. When the permafrost melts the methane that will be released can accelerate the process of global warming.

Control measures for air pollution

Air pollution can be controlled by two fundamental approaches: preventive techniques and effluent control.

One of the effective means of controlling air pollution is to have proper equipment in place. This includes devices for removal of pollutants from the flue gases through scrubbers, closed collection recovery systems through which it is possible to collect the pollutants before they escape, use of dry and wet collectors, filters, electrostatic precipitators, etc. Providing a greater height to the stacks can help in facilitating the discharge of pollutants as far away from the ground as possible. Industries should be located in places so as to minimize the effects of pollution after considering the topography and the wind directions. Substitution of raw material that causes more

is another source of pollution. Accidental oil spills from large transport tankers at sea have been causing significant environmental damage.

Though accidents such as the *Exxon Valdez* get worldwide attention, much more oil is released as a result of small, regular releases from other less visible sources. Nearly two thirds of all marine oil pollution comes from three sources: run-off from streets, improper discharge of lubricating oil from machines or automobile crankcases and intentional oil discharges that occur during the loading and unloading of tankers. Oil tankers often use sea water as ballast to stabilize the ship after they have discharged their oil. This oil contaminated water is then discharged back into the sea when the tanker is refilled.

Groundwater pollution: While oil spills are highly visible and often get a lot of media attention, a much greater threat to human life comes from our groundwater being polluted which is used for drinking and irrigation. While groundwater is easy to deplete and pollute it gets renewed very slowly and hence must be used judiciously. Groundwater flows are slow and not turbulent hence the contaminants are not effectively diluted and dispersed as compared to surface water. Moreover, pumping groundwater and treating it is very slow and costly. Hence it is extremely essential to prevent the pollution of groundwater in the first place. Ground water is polluted due to:

- Urban run-off of untreated or poorly treated waste water and garbage
- Industrial waste storage located above or near aquifers
- Agricultural practices such as the application of large amounts of fertilizers and pesticides, animal feeding operations, etc. in the rural sector

- Leakage from underground storage tanks containing gasoline and other hazardous substances
- Leachate from landfills
- Poorly designed and inadequately maintained septic tanks
- Mining wastes

Severe cases of arsenic poisoning from contaminated groundwater have been reported from West Bengal in what is known today as the worst case of groundwater pollution. The School of Environmental Sciences, Jadavpur University, West Bengal has been involved in the task of surveying the magnitude of the arsenic problem in West Bengal for the last fourteen years. According to a report in the *Down to Earth* (Vol. 11, No.22), arsenic poisoning was first noticed by K C Saha, former professor of dermatology at the School of Tropical Medicine, Kolkata when he began to receive patients with skin lesions that resembled the symptoms of leprosy which was in reality not leprosy. Since all the patients were from the district of 24-Parganas, Saha along with others began to look for the cause and found it to be arsenic toxicity. Thus groundwater arsenic contamination in West Bengal was first reported in a local daily newspaper in December 1983 when 63 people from three villages located in different districts were identified by health officials as suffering from arsenic poisoning.

There are two theories that have been put forth to explain this unusually high content of arsenic in groundwater. One group of researchers suggested that the cause is natural while the other stated that the cause is man-made.

According to the first hypothesis, arsenic probably originates in the Himalayan headwaters of the Ganga and the Brahmaputra rivers and has been lying undisturbed beneath the surface of

where most of the microorganisms settle out as sludge. This sludge is then broken down in an anaerobic digester where methane-forming bacteria slowly convert the organic matter into carbon dioxide, methane and other stable end products. The gas produced in the digester is 60 percent methane, which is a valuable fuel and can be put to many uses within the treatment plant itself. The digested sludge, which is still liquid, is normally pumped out onto sludge drying beds where evaporation and seepage remove the water. This dried sludge is potentially a good source of manure. Activated sludge tanks use less land area than trickling filters with equivalent performance. They are also less expensive to construct than trickling filters and have fewer problems with flies and odour and can also achieve higher rates of BOD removal. Thus although the operating costs are a little higher due to the expenses incurred on energy for running pumps and blowers they are preferred over trickling filters.

Oxidation ponds are large shallow ponds approximately 1 to 2 metres deep where raw or partially treated sewage is decomposed by microorganisms. They are easy to build and manage and accept a large fluctuation in flow and can provide treatment at a much lower cost. They however require a large amount of land and hence can be used where land is not a limitation.

Advanced sewage treatment: This involves a series of chemical and physical process that removes specific pollutants left in the water after primary and secondary treatment. Sewage treatment plant effluents contain nitrates and phosphates in large amounts. These contribute to eutrophication. Thus advanced treatment plants are designed to specifically remove these contaminants. Advanced treatment plants are very expensive to build and operate and hence are rarely used.

Pollution due to oil: Oil pollution of the sea normally attracts the greatest attention because of its visibility. There are several sources though which the oil can reach the sea.

Tanker operations

Half the world production of crude oil which is close to three billion tones a year is transported by sea. After a tanker has unloaded its cargo of oil it has to take on seawater as ballast for the return journey. This ballast water is stored in the cargo compartments that previously contained the oil. During the unloading of the cargo a certain amount of oil remains clinging to the walls of the container and this may amount to 800 tonnes in a 200,000 tonne tanker. The ballast water thus becomes contaminated with this oil. When a fresh cargo of oil is to be loaded, these compartments are cleaned with water which discharges the dirty ballast along with the oil into the sea. Two techniques have substantially reduced this oil pollution. In the *load-on-top* system the compartments are cleaned by high pressure jets of water. The oily water is retained in the compartment until the oil floats to the top. The water underneath that contains only a little oil is then discharged into the sea and the oil is transferred to a slop tank. At the loading terminal, fresh oil is loaded on top of the oil in the tank and hence the name of the technique. In the second method called '*crude oil washing*', the clingage is removed by jets of crude oil while the cargo is being unloaded. Some modern tankers have *segregated ballast* where the ballast water does not come in contact with the oil. Thus with the introduction of these new methods of deballasting, the amount of oil entering the sea has been considerably reduced.

Dry docking

All ships need periodic dry docking for servicing, repairs, cleaning the hull, etc. During this period when the cargo compartments are to

Fish and shellfish production facilities can also be affected by oil slicks. The most important commercial damage can however also come from tainting which imparts an unpleasant flavour to fish and seafood and is detectable at extremely low levels of contamination. This reduces the market value of seafood.

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Decibel levels of common sound

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30	Bedroom at night
40	Library
50	Quiet office
60	Conversational speech (at 1m)
70	Average radio
74	Light traffic noise
90	Subway train
100	Symphony orchestra
110	Rock band
120	Aircraft takeoff
146	Threshold of pain

Effects of noise pollution on physical health

The most direct harmful effect of excessive noise is physical damage to the ear and the temporary or permanent hearing loss often called a temporary threshold shift (TTS). People suffering from this condition are unable to detect weak sounds. However hearing ability is usually recovered within a month of exposure. In Maharashtra people living in close vicinity of Ganesh mandals that play blaring music for ten days of the Ganesh festival are usually known to suffer from this phenomenon. Permanent loss, usually called noise induced permanent threshold shift (NIPTS) represents a loss of hearing ability from which there is no recovery.

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minum foil, metal items, wood pieces, etc. which is classified as dry garbage.

Control measures of urban and industrial wastes: An integrated waste management strategy includes three main components:

1. Source reduction
2. Recycling
3. Disposal

Source reduction is one of the fundamental ways to reduce waste. This can be done by using less material when making a product, reuse of products on site, designing products or packaging to reduce their quantity. On an individual level we can reduce the use of unnecessary items while shopping, buy items with minimal packaging, avoid buying disposable items and also avoid asking for plastic carry bags.

Recycling is reusing some components of the waste that may have some economic value. Recycling has readily visible benefits such as conservation of resources reduction in energy used during manufacture and reducing pollution levels. Some materials such as aluminum and steel can be recycled many times. Metal, paper, glass and plastic are recyclable. Mining of new aluminum is expensive and hence recycled aluminum has a strong market and plays a significant role in the aluminum industry. Paper recycling can also help preserve forests as it takes about 17 trees to make one ton of paper. Crushed glass (cullet) reduces the energy required to manufacture new glass by 50 percent. Cullet lowers the temperature requirement of the glassmaking process thus conserving energy and reducing air pollution. However even if recycling is a viable alternative, it presents several problems.

The problems associated with recycling are either technical or economical. Plastics are difficult to recycle because of the different types of polymer resins used in their production. Since each type has its own chemical makeup differ-

ent plastics cannot be recycled together. Thus separation of different plastics before recycling is necessary. Similarly in recycled paper the fibers are weakened and it is difficult to control the colour of the recycled product. Recycled paper is banned for use in food containers to prevent the possibility of contamination. It very often costs less to transport raw paper pulp than scrap paper. Collection, sorting and transport account for about 90 percent of the cost of paper recycling. The processes of pulping, deinking and screening wastepaper are generally more expensive than making paper from virgin wood or cellulose fibers. Very often thus recycled paper is more expensive than virgin paper. However as technology improves the cost will come down.

Disposal of solid waste is done most commonly through a sanitary landfill or through incineration. A modern sanitary landfill is a depression in an impermeable soil layer that is lined with an impermeable membrane. The three key characteristics of a municipal sanitary landfill that distinguish it from an open dump are:

- Solid waste is placed in a suitably selected and prepared landfill site in a carefully prescribed manner.
- The waste material is spread out and compacted with appropriate heavy machinery.
- The waste is covered each day with a layer of compacted soil.

The problem with older landfills are associated with groundwater pollution. Pollutants seeping out from the bottom of a sanitary landfill (leachates) very often percolate down to the groundwater aquifer no matter how thick the underlying soil layer. Today it is essential to have suitable bottom liners and leachate collection systems along with the installation of monitoring systems to detect groundwater pollution. The organic material in the buried solid waste

Steps for Vermi-Compost

- Dig a pit about half a meter square, one meter deep.
- Line it with straw or dried leaves and grass.
- Organize the disposal of organic waste into the pit as and when generated.
- Introduce a culture of worms that is now produced commercially.
- Ensure that the contents are covered with a sprinkling of dried leaves and soil everyday.
- Water the pit once or twice a week to keep it moist.
- Turn over the contents of the pit ever 15 days.
- In about 45 days the waste will be decomposed by the action of the microorganisms.
- The soil derived is fertile and rich in nutrients.

Hazardous wastes

Modern society produces large quantities of hazardous waste which are generated by chemical manufacturing companies, petroleum refineries, paper mills, smelters and other industries. Hazardous wastes are those that can cause harm to humans or the environment. Wastes are normally classified as hazardous waste when they cause or significantly contribute to an increase in mortality or an increase in serious irreversible or incapacitating reversible illness or pose a sub-

stantial present or potential hazard to human health or the environment when improperly treated, stored, transported or disposed of.

Characteristics of hazardous wastes

A waste is classified as a hazardous waste if it exhibits any of the four primary characteristics based on the physical or chemical properties of toxicity, reactivity, ignitability and corrosivity. In addition to this waste products that are either infectious or radioactive are also classified as hazardous

Toxic wastes are those substances that are poisonous even in very small or trace amounts. Some may have an acute or immediate effect on humans or animals causing death or violent illness. Others may have a chronic or long term effect slowly causing irreparable harm to exposed persons. Acute toxicity is readily apparent because organisms respond to the toxin shortly after being exposed. Chronic toxicity is much more difficult to determine because the effects may not be seen for years. Certain toxic wastes are known to be carcinogenic, causing cancer and others may be mutagenic causing biological changes in the children of exposed people and animals.

Reactive wastes are those that have a tendency to react vigorously with air or water, are unstable to shock or heat, generate toxic gases or explode during routine management. For example, gunpowder, nitroglycerine, etc.

Ignitable wastes are those that burn at relatively low temperatures (less than 60 C) and are capable of spontaneous combustion during storage, transport or disposal. For example, gasoline, paint thinners, and alcohol.

Corrosive wastes are those that destroy materials and living tissue by chemical reaction. For example, acids and bases.

people may feel that environmental problems can be solved with quick technological fixes. While a majority of individuals would want a cleaner environment, not many of them want to make major changes in their lifestyle that could contribute to a cleaner environment. Decisions and actions taken by individuals to a very large extent determine the quality of life for everyone. This necessitates that individuals should not only be aware of various environmental issues and the consequences of their actions on the environment but should also make a firm resolve to develop environmentally ethical lifestyles.

With the help of solar energy, natural processes developed over billions of years can indefinitely renew the topsoil, water, air, forests, grasslands and wildlife on which all forms of life depend, but only as long as we do not use these potentially renewable resources faster than they are replenished. Some of our wastes can be diluted, decomposed and recycled by natural processes indefinitely as long as these processes are not overloaded. Natural processes also provide services of flood prevention, erosion control at no costs at all. We must therefore learn to value these resources and use them sustainably.

Concepts that help individuals contribute towards a better quality of our environment and human life.

- Develop respect or reverence for all forms of life.
- Each individual must try to answer four basic questions:
Where do the things that I consume come from?
What do I know about the place where I live?
How am I connected to the earth and other living things?
What is my purpose and responsibility as a human being?

- Try to plant trees wherever you can and more importantly take care of them. They reduce air pollution.
- Reduce the use of wood and paper products wherever possible. Manufacturing paper leads to pollution and loss of forests which releases oxygen and takes up carbon dioxide. Try to recycle paper products and use recycled paper wherever possible.
- From the mail you receive reuse as many envelopes that you can.
- Do not buy furniture, doors, window frames made from tropical hardwoods such as teak and mahogany. These are forest based.
- Help in restoring a degraded area near your home or join in an afforestation program.
- Use pesticides in your home only when absolutely necessary and use them in as small amounts as necessary. Some insect species help to keep checked on the populations of pest species.
- Advocate organic farming by asking your grocery store to stock vegetables and fruits grown by an organic method. This will automatically help to reduce the use of pesticides.
- Reduce the use of fossil fuels by either walking up a short distance using a car pool, sharing a bike or using public transport. This reduces air pollution.
- Shut off the lights and fans when not needed.
- Don't use aerosol spray products and commercial room air fresheners. They damage the ozone layer.

the pre-disaster, during disaster and post disaster plans. Since their activities are complementary as well as supplementary to each other there is a critical need for coordinating these activities.

In order to transfer the benefits of scientific research and development to the communities links must be developed between scientific communities and field agencies. Coordination between Government agencies and NGOs needs to be built up so that overlap of activities may be avoided and linkages between the Government and communities are established.

Today we have a range of early warning systems for a range of natural hazards. Although they are more accurate than before and can help in prediction it is not enough to ensure communities are safe from disasters. This is where disaster mitigation can play an important role. Mitigation means lessening the negative impact of the natural hazards. It is defined as sustained action taken to reduce long term vulnerability of human life and property to natural hazards. While the preparatory, response and the recovery phases of emergency management relate to specific events, mitigation activities have the potential to produce repetitive benefits over time.

Certain guidelines if followed can result in an effective mitigation program.

- Pre-disaster mitigation can help in ensuring faster recovery from the impacts of disasters.
- Mitigation measures must ensure protection of the natural and cultural assets of the community.
- Hazard reduction methods must take into account the various hazards faced by the affected community and their desires and priorities.

- Any mitigation program must also ensure effective partnership between Government, scientific, private sector, NGOs and the community.

The main elements of a mitigation strategy are as follows:

Risk assessment and Vulnerability analysis

This involves identification of hot spot areas of prime concern, collection of information on past natural hazards, information of the natural ecosystems and information on the population and infrastructure. Once this information is collected a risk assessment should be done to determine the frequency, intensity, impact and the time taken to return to normalcy after the disaster. The assessment of risk and vulnerabilities will need to be revised periodically. A regular mechanism will therefore have to be established for this. The use of Geographical Information Systems (GIS) a computer program can be a valuable tool in this process as the primary data can be easily updated and the corresponding assessments can be made.

Applied research and technology transfer

There is a need to establish or upgrade observation equipment and networks, monitor the hazards properly, improve the quality of forecasting and warning, disseminate information quickly through the warning systems and undertake disaster simulation exercises.

Thus space technologies such as remote sensing, satellite communications and Global Positioning Systems have a very important role to play. Government organizations like ISRO (Indian Space Research Organization) can play a vital role. Similarly Government organizations the National Building Research Organization, the Meteorological Department, Irrigation Department, etc. can undertake applied research for devising locale specific mitigation strategies in

collaboration with educational institutions or Universities.

Such steps could lead to the formulation of locale specific mitigation measures. A combination of scientific knowledge and expertise with the community based mitigation measures would not only enhance the database but would also form the basis of a successful mitigation strategy.

Public awareness and training

One of the most critical components of a mitigation strategy is the training to be imparted to the officials and staff of the various departments involved at the state and the district level. This enables sharing of information and methodology. The success of a mitigation strategy will depend to a large extent on the inter-sectional, inter-departmental coordination and efficient teamwork. Thus a training program that is designed after assessment of gaps in knowledge, skills and attitude with respect to the various tasks that need to be undertaken is a vital component.

Institutional mechanisms

The most important need at the National level is to strengthen or develop the capacity to undertake disaster mitigation strategies. There is a need to emphasize on proactive and pre-disaster measures rather than post disaster response. It is thus essential to have a permanent administrative structure which can monitor the developmental activities across departments and provides suggestions for necessary mitigation measures. The National Disaster Management Center (NDMC) can perform such a task. Professionals like architects, structural engineers, doctors, chemical engineers who are involved with management of hazardous chemicals can be asked to form groups that can design specific mitigation measures.

Incentives and resources for mitigation

To a very large extent the success of mitigation programs will depend upon the availability of continued funding. There is thus a need to develop mechanisms to provide stable sources of funding for all mitigation programs. This will include incentives for relocation of commercial and residential activities outside the disaster prone areas. Housing finance companies should make it mandatory for structures in such hazard prone areas to follow special building specifications. The introduction of disaster linked insurance should be explored and should cover not only life but also household goods, cattle, structures and crops.

Landuse planning and regulations

Long term disaster reduction efforts should aim at promoting appropriate land-use in the disaster prone areas. Separation of industrial areas from residential areas, maintaining wetlands as buffer zones for floods, creation of public awareness of proper land practices and formation of land-use policies for long term sustainable development is imperative.

Hazard resistant design and construction

In areas that are prone to disasters protection can be enhanced by careful selection of sites and the way the buildings are built. Thus it is essential to promote the knowledge of disaster resistant construction techniques and practices among engineers, architects and technical personnel.

Structural and Constructional reinforcement of existing buildings

It is also possible to reduce the vulnerability of existing buildings through minor adaptations or alterations thereby ensuring their safety. This can be done by insertion of walls on the outside of the building, buttresses, walls in the interior of the building, portico fill-in-walls, specially an-

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and most sponges, mollusks and crustaceans are eliminated at temperatures above 37°C. This results in a change in the diversity of fauna as only those species that can live in warmer water survive.

Control measures: Thermal pollution can be controlled by passing the heated water through a cooling pond or a cooling tower after it leaves the condenser. The heat is dissipated into the air and the water can then be discharged into the river or pumped back to the plant for reuse as cooling water. There are several ways in which thermal pollution can be reduced. One method is to construct a large shallow pond. Hot water is pumped into one end of the pond and cooler water is removed from the other end. The heat gets dissipated from the pond into the atmosphere. A second method is to use a cooling tower. These structures take up less land area than the ponds. Here most of the heat transfer occurs through evaporation. Here warm waters coming from the condenser is sprayed downward over vertical sheets or baffles where the water flows in thin films. Cool air enters the tower through the water inlet and rises to the base of the tower and rises upwards causing evaporative cooling. A natural draft is maintained because of the density difference between the cool air outside and the warmer air inside the tower. The waste heat is dissipated into the atmosphere about 100 m above the base of the tower. The cooled water is collected at the floor of the tower and recycled back to the power plant condensers. The disadvantage in both these methods is however that large amounts of water are lost by evaporation.

5.2.7 Nuclear Hazards

Nuclear energy can be both beneficial and harmful depending on the way in which it is used. We routinely use X-rays to examine bones for fractures, treat cancer with radiation and diagnose diseases with the help of radioactive iso-

topes. Approximately 17 % of the electrical energy generated in the world comes from nuclear power plants. However on the other hand it is impossible to forget the destruction that nuclear bombs caused the cities of Hiroshima and Nagasaki. The radioactive wastes from nuclear energy have caused serious environmental damage.

Nuclear fission is the splitting of the nucleus of the atom. The resulting energy can be used for a variety of purposes. The first controlled fission of an atom was carried out in Germany in 1938. However the United States was the first country to develop an atomic bomb which was subsequently dropped on the Japanese cities of Hiroshima and Nagasaki. The world's first electricity generating reactor was constructed in the United States in 1951 and the Soviet Union built its first reactor in 1954. In December 1953, President Dwight D. Eisenhower in his 'Atoms for Peace' speech made the following prediction: *'Nuclear reactors will produce electricity so cheaply that it will not be necessary to meter it. The users will pay a fee and use as much electricity as they want. Atoms will provide a safe, clean and dependable source of electricity.'*

Today however though nuclear power is being used as a reliable source of electricity the above statement sounds highly optimistic. Several serious accidents have caused worldwide concern about safety and disposal of radioactive wastes.

In order to appreciate the consequences of using nuclear fuels to generate energy it is important to understand how the fuel is processed. Low-grade uranium ore, which contains 0.2 percent uranium by weight, is obtained by surface or underground mining. After it is mined the ore goes through a milling process where it is crushed and treated with a solvent to concentrate the uranium and produces yellow cake a material containing 70 to 90 percent uranium oxide. Naturally occurring uranium contains only 0.7 percent of fissionable U-235, which is not

Infectious wastes include human tissue from surgery, used bandages and hypodermic needles, microbiological materials, etc.

Radioactive waste is basically an output from the nuclear power plants and can persist in the environment for thousands of years before it decays appreciably.

Environmental problems and health risks caused by hazardous wastes.

As most of the hazardous wastes are disposed of on or in land the most serious environmental effect is contaminated groundwater. Once groundwater is polluted with hazardous wastes it is very often not possible to reverse the damage.

Pesticides are used increasingly to protect and increase food production. They form residues in the soil which are washed into streams which then carry them forwards. The residues may persist in the soil or in the bottom of lakes and rivers. Exposure can occur through ingestion, inhalation and skin contact, resulting in acute or chronic poisoning. Today we have an alternative to the excess use of pesticides through the use of Integrated Pest Management (IPM). The IPM system uses a wide variety of plants and insects to create a more natural process. The natural balance between climate, soil and insect populations can help to prevent an insect from overpopulating an area and destroying a particular crop.

Lead, mercury and arsenic are hazardous substances which are often referred to as heavy metals. Lead is an abundant heavy metal and is relatively easy to obtain. It is used in batteries, fuel, pesticides, paints, pipes and other places where resistance to corrosion is required. Most of the lead taken up by people and wildlife is stored in bones. Lead can affect red blood cells by reducing their ability to carry oxygen and

shortening their life span. Lead may also damage nerve tissue which can result in brain disease.

Mercury occurs in several different forms. Mercury is used in the production of chlorine. It is also used as a catalyst in the production of some plastics. Industrial processes such as the production of chlorine and plastics are responsible for most of the environmental damage resulting from mercury. Our body has a limited ability to eliminate mercury. In the food web mercury becomes more concentrated as it is taken up by various organisms. In an aquatic environment, mercury can be absorbed by the plankton which are then consumed by fish. In addition, fish take up mercury through their gills and by eating

Minamata-An important lesson about mercury

A case of human mercury poisoning which occurred about forty years ago in the Minamata bay in Japan taught the world an important lesson about the dangers of mercury poisoning. A large plastics plant located near the Minamata bay used a mercury containing compound in a reaction to produce vinyl chloride a common plastic material. The left over mercury was dumped into the Bay along with other wastes from the plant. Though the mercury was in its less toxic inorganic state when dumped microorganisms at the bottom of the bay converted the mercury into its organic form. This organic mercury then entered into the tissues of fish which were in turn consumed by the people living in the area. The contaminated fish thus caused an outbreak of poisoning killing and affecting several people. Mothers who had eaten the contaminated fish gave birth to infants who showed signs of mercury poisoning. Mercury poisoning is thus called Minamata Disease.

people may feel that environmental problems can be solved with quick technological fixes. While a majority of individuals would want a cleaner environment, not many of them want to make major changes in their lifestyle that could contribute to a cleaner environment. Decisions and actions taken by individuals to a very large extent determine the quality of life for everyone. This necessitates that individuals should not only be aware of various environmental issues and the consequences of their actions on the environment but should also make a firm resolve to develop environmentally ethical lifestyles.

With the help of solar energy, natural processes developed over billions of years can indefinitely renew the topsoil, water, air, forests, grasslands and wildlife on which all forms of life depend, but only as long as we do not use these potentially renewable resources faster than they are replenished. Some of our wastes can be diluted, decomposed and recycled by natural processes indefinitely as long as these processes are not overloaded. Natural processes also provide services of flood prevention, erosion control at no costs at all. We must therefore learn to value these resources and use them sustainably.

Concepts that help individuals contribute towards a better quality of our environment and human life.

- Develop respect or reverence for all forms of life.
- Each individual must try to answer four basic questions:
Where do the things that I consume come from?
What do I know about the place where I live?
How am I connected to the earth and other living things?
What is my purpose and responsibility as a human being?

- Try to plant trees wherever you can and more importantly take care of them. They reduce air pollution.
- Reduce the use of wood and paper products wherever possible. Manufacturing paper leads to pollution and loss of forests which releases oxygen and takes up carbon dioxide. Try to recycle paper products and use recycled paper wherever possible.
- From the mail you receive reuse as many envelopes that you can.
- Do not buy furniture, doors, window frames made from tropical hardwoods such as teak and mahogany. These are forest based.
- Help in restoring a degraded area near your home or join in an afforestation program.
- Use pesticides in your home only when absolutely necessary and use them in as small amounts as necessary. Some insect species help to keep checked on the populations of pest species.
- Advocate organic farming by asking your grocery store to stock vegetables and fruits grown by an organic method. This will automatically help to reduce the use of pesticides.
- Reduce the use of fossil fuels by either walking up a short distance using a car pool, sharing a bike or using public transport. This reduces air pollution.
- Shut off the lights and fans when not needed.
- Don't use aerosol spray products and commercial room air fresheners. They damage the ozone layer.

spectful in doing so as you will gain little by being hostile and brash.

- Take care to put into practice what you preach. Remember environment protection begins with YOU.

5.5 POLLUTION CASE STUDIES

A case study of groundwater pollution in India

An example of groundwater pollution caused by excessive extraction is that fluoride contamination. Fluorosis is not a localized problem. It has spread across 19 states and across a variety of ecological regions ranging from the Thar desert, the Gangetic plains and the Deccan plateau. Each of these regions are distinct in terms of rainfall, soil type, groundwater recharge regime, climatic conditions and hydrology. High fluoride concentration in groundwater is a natural phenomenon in several countries such as China, Sri Lanka, West Indies, Spain, Holland, Italy and Mexico. Experts claim that a fluoride belt stretches across the Middle East across Pakistan and India and then into Southeast Asia and the South of China. According to a report of the Rajiv Gandhi National Drinking Water mission, the bedrock of the Indian peninsula consists of a number of fluoride bearing minerals. When the bedrock weathers the fluoride leaches into water and the soil. Although the Indian peninsular bedrock has always been the same, this problem has only surfaced during the last three decades. This is related to the over extraction of groundwater which has resulted in the tapping of aquifers with high fluoride concentrations.

The beginnings of this phenomenon can be traced back to the 1970s and the 1980s when there was massive state investment in rural water development for irrigation as well as for drinking. Encouraged by state subsidies on diesel and electricity, people invested in diesel and

submersible pumps in a bid to extract groundwater through borewells. This policy aggravated the fluoride problem.

Fluoride mainly enters the human body through drinking water where 96 to 99 percent of it combines with the bones as it has an affinity for calcium phosphate in the bones. Excess intake of fluoride can lead to dental fluorosis, skeletal fluorosis or non-skeletal fluorosis. Dental fluorosis is characterized by discoloured, blackened, mottled or chalky white teeth. Skeletal fluorosis leads to severe and permanent bone and joint deformities. Non-skeletal fluorosis leads to gastro-intestinal problems and neurological disorders. Fluoride can damage the foetus and adversely affect the IQ of children.

Once fluoride is detected in water, the only solution is to defluoridate it. Various technologies are available for this process. However, the type of technology to be selected depends upon the fluoride level in the water and the volume of water to be defluoridated. None of the Indian technologies are fool-proof. Defluoridation plants and household water treatment kits are stop-gap solutions.

A case study of pesticide pollution in India

One of the most terrifying effects of pesticide contamination of ground water came to light when pesticide residues were found in bottled water. Between July and December 2002, the Pollution Monitoring Laboratory of the New Delhi based Center for Science and Environment (CSE) analysed 17 brands of bottled water both packaged drinking water and packaged natural mineral water commonly sold in areas that fall within the national capital region of Delhi. Pesticide residues of organochlorine and organophosphorus pesticides which are most commonly used in India were found in all the samples. Among organochlorines, gamma-hexachlorocyclohexane (lindane) and DDT were

We as citizens of our Nation, and increasingly as citizens of one common future at the global level, must constantly monitor the pattern of development. If we see that a development project or an industry is leading to serious environmental problems, it is our duty to bring this to the attention of authorities such as the local administration, the Forest Department or the Pollution Control Board, to look into the issue. Further if new development projects are being planned in and around the place where we live it is our duty to see that this is brought about in accordance with environmental safeguards. While we all need to think globally, we need to act locally. We have to see to it that we change development from its present mandate of rapid economic growth without a thought for future ecological integrity, to a more sustainable ecologically appropriate strategy.

If new projects of a large size are to be passed Government has made it compulsory to publish the summary report of the Environmental Impact Assessment (EIA) and conduct a 'Public Hearing'. It is essential that all of us as responsible citizens read, evaluate and respond to such public hearings held in our area and make comments on the possible impacts of the project. In many situations there are promoters of the project who only look at their own rapid economic gains. It is for citizens as concerned individuals and groups to counter these vested interests so that our environment is not degraded further. Life has to be made more livable for all. We cannot support the economic growth of one sector of society while we permit environmental degradation to destroy the lives of the less fortunate.

6.2 URBAN PROBLEMS RELATED TO ENERGY

Urban centers use enormous quantities of energy. In the past, urban housing required relatively smaller amounts of energy than we use at present. Traditional housing in India required

very little temperature adjustments as the materials used, such as wood and bricks handled temperature changes better than the current concrete, glass and steel of ultra modern buildings.

Embodied energy

Materials like iron, glass, aluminium, steel, cement, marble and burnt bricks, which are used in urban housing, are very energy intensive. The process of extraction, refinement, fabrication and delivery are all energy consuming and add to pollution of earth, air and water. This energy consumed in the process is called embodied energy.

Until the 1950s many urban kitchens were based on fuelwood or coal. This was possible and practical when homes had chimneys and kitchens were isolated from the rest of the house. Smoke became a problem once this changed to apartment blocks. Kerosene thus became a popular urban fuel. This changed to electrical energy and increasingly to natural gas by the 1970s in most parts of urban India.

Urban centers in hot climates need energy for cooling. The early systems of fans changed into air-conditioning, which consumes enormous quantities of energy. New buildings in our country have taken to using large areas covered by glass. While in cold climates this uses the green house effect to trap the warmth of the sun inside, in our hot climate this adds several degrees to the temperature inside. Thus it requires even more energy to run large central air conditioning units. High rise buildings in urban centers also depend on energy to operate lifts and an enormous number of lights.

school and college level are being reoriented to bring this about.

The Gandhian way of life

Mahatma Gandhi had deep insights into the need to conserve resources. 'Mans needs but not his greed can be supported by our earth' was an important concept that was initiated by him when people had not realized how short the world would be of resources in future. At the time natural resources seemed to be limitless to most people. This was thus a new concept and suggested the need for a uniquely different pattern of living.

Gandhiji believed in simplistic living to save our earth's resources. He once said that if India was to become an industrial nation on the lines of England, the world itself would be stripped bare of its resources by India's people alone.

Education in nature – The Shantiniketan model

Rabindranath Tagore founded Shantiniketan and taught an environment-based philosophy. Tagore's philosophy of education focused attention on the need for a harmonious association between human beings and their environment. To achieve this he relied on exposing young people to nature. This went back to our roots where in ancient India, learning centers were established in remote forests. Tagore linked these concepts with celebrations of nature through music, dance, drama and poetry. At Shantiniketan, there were celebrations for each season and ceremonial tree planting. He started Vriksha ropan way back in 1928. In fact much of what was initiated in Shantiniketan is now accepted as the route to environment education and sustainable living and is essentially based on preserving nature.

There are two aspects that are closely connected with ethical issues that are related to environment. These are based on *valuing nature* and *appreciating the beauty of nature* and *treasuring the magnificence of the wilderness*.

Valuing nature as a resource: It is essential that a value system that is based on environmental concern becomes a part of the thinking that we as responsible citizens of our country and our earth need to bring into our own daily lives. For our ancestors, Nature was considered to be like a mother. This has been essentially forgotten. In ancient India, forests were considered sacred. We now know that forests clean up our air, and act like a sponge that can hold water for the dry season. In the Hindu scriptures, Buddhist philosophy and especially in the Jain religion, each and every species on earth is supposed to have a place in the scheme of life.

Many species were not only valued, but also venerated.

In today's world where many of us are far removed from nature, we need to remind ourselves that everything we use, if tracked back to its source, has come from nature. We depend on an intact unpolluted world which is based on nature's goods and services. No life is possible without this. If we as citizens begin to again respect Nature and all its varied species forming a complex web of life, and appreciate Nature's functions and services, it will continue to support our lives. If we disrespect nature one cannot expect her to continue to support our well being. Nature's resources that we all use and depend on can only be optimized if they are equitably shared by all of us. If the disparity is too great it can only result in anarchy. The 'have not's' cannot be expected to remain in

that are transmitted by mosquitoes (dengue, yellow fever) and by ticks (Lyme disease, tick-borne encephalitis) may spread due to climate change.

CASE STUDIES

Damage to coral reefs, Pacific

The severity of periodic warming due to El Nino in 1997 in the Pacific led to the most serious death in coral ever known. It is estimated that about 10% of the Earth's coral reefs were dead, another 30 % were seriously affected and another 30% were degraded.

The Global Coral Reef Monitoring Network Townsville, Australia, has predicted that all the reefs could be dead by 2050.

Butterfly populations in the United Kingdom

Global warming is leading to an early arrival of butterflies in Britain. Scientists say that butterflies can now be spotted much earlier every year in the last two decades. Some, like the red admiral, can now be seen a month earlier than was the case in the mid – 1970s. Others, like the peacock and the orange tip are appearing between 15 and 25 days earlier than in the past. Future rise in temperature is likely to have a detrimental effect on these butterflies. Some butterflies which need cooler temperatures might suffer.

A Task Group set up by WHO has warned that climate change may have serious impacts on human health. Climate change will increase various current health problems, and may also bring

new and unexpected ones. Strategies aimed at reducing potential health impacts of anticipated climate changes should include monitoring of infectious diseases and disease vectors to detect early changes in the incidence of diseases and the geographical distribution of vectors; environmental management measures to reduce risk; disaster preparedness for floods or droughts; and their health related consequences. It will be necessary to create early warning systems and education for epidemic preparedness. Improved water and air pollution control will become increasingly essential for human health. Public education will have to be directed at changes in personal behaviour. Training of researchers and health professionals must become an essential part of the world becoming more responsible towards the expected outcome of Global Climate Change (GCC).

6.6.2 Global warming

About 5% of the solar energy reaching the Earth is absorbed by the earth's surface which increases in temperature. The rest of the heat radiates back to the atmosphere. Some of the heat is trapped by greenhouse gases, mostly carbon dioxide. As carbon dioxide is released by various human activities, it is rapidly increasing. This is causing global warming.

The average surface temperature is about 15°C. This is about 33°C higher than it would be in the absence of the greenhouse effect. Without such gases most of the Earth's surface would be frozen with a mean air temperature of -18°C.

Human activities during the last few decades of industrialisation and population growth have polluted the atmosphere to the extent that it has begun to seriously affect the climate. Carbon dioxide in the atmosphere has increased by 31% since pre-industrial times, causing more heat to be trapped in the lower atmosphere. There is evidence to show that carbon dioxide

around. The effects of the radiation from these nuclear bombs can still be seen today in the form of cancer and genetic mutations in the affected children and survivors of the incident.

6.7 WASTELAND RECLAMATION

Loss of vegetation cover leads to loss of soil through erosion, which ultimately creates wastelands. This is one of the pressing problems of the country. Loss of soil has already ruined a large amount of cultivable land in our country. If it remains unchecked, it will affect the remaining land. Unless we adequately safeguard our 'good' lands, we may eventually face a serious shortage of food grains, vegetables, fruit, fodder and fuel wood. Hence, conservation of soil, protecting the existing cultivable land and reclaiming the already depleted wastelands figures prominently among the priority tasks of planning for the future. Some of the wasteland reclamation programs have been unsuccessful because after sometime the land reverts to its original poor condition due to mismanagement and unscientific ways in which the reclamation has been carried out.

In choosing wasteland reclamation methods attention must be paid to the cost factor. This has to be taken into account before deciding on a particular method for reclamation of wastelands. A proper study of environmental aspects and human impacts which are responsible for the development of wastelands have to be looked into.

Wasteland can be classified into three forms: (1) Easily reclaimable, (2) Reclaimable with some difficulty, (3) Reclaimable with extreme difficulty.

Easily reclaimable wastelands can be used for agricultural purposes. Those which can be reclaimed with some difficulty can be utilized for agro forestry. Wastelands that are reclaimed

with extreme difficulty can be used for forestry or to recreate natural ecosystems.

Agriculture: Wasteland can be reclaimed for agriculture by reducing the salt content which can be done by leaching and flushing. Gypsum, urea, potash and compost are added before planting crops in such areas.

Agro forestry: This involves putting land to multiple uses. Its main purpose is to have trees and crops inter- and /or under planted to form an integrated system of biological production within a certain area. Thus, agro forestry implies integration of trees with agricultural crops or live-stock management simultaneously.

Forestry: Attempts to grow trees in highly non alkaline saline soils have been largely unsuccessful. Field experiments have shown that species like Eucalyptus, Prosopis and Acacia nilotica could not be grown in highly alkaline soil. Studies have shown that if tree seedlings are planted with a mixture of original soil, Gypsum, and manure, better growth can be achieved. It is however important to use indigenous species of trees so that the program recreates the local ecosystem with all its species.

Need for wasteland development:

Wasteland development provides a source of income for the rural poor. It ensures a constant supply of fuel, fodder and timber for local use. It makes the soil fertile by preventing soil erosion and conserving moisture. The program helps maintain an ecological balance in the area. The increasing forest cover helps in maintaining local climatic conditions. Regenerated vegetation cover helps in attracting birds which feed on pests in the surrounding fields and function as natural pest controllers. The trees help in holding back moisture and reduce surface run off rates thus helping in the control of soil erosion.

and their notification. It establishes the structure of the State's wildlife management and the posts designated for Wildlife Management. It provides for setting up Wildlife Advisory Boards. It prohibits hunting of all animals specified in Schedules I to IV of the Act. These are notified in order of their endangeredness. Plants that are protected are included in schedule VI.

The Amendment to the Wildlife Protection Act in 2002 is more stringent and prevents the commercial use of resources by local people. It has brought in new concepts such as the creation of Community Reserves. It has also altered several definitions. For instance in animals, fish are now included. Forest produce has been redefined to ensure protection of ecosystems.

While there are several changes, the new Act still has serious issues concerned with its implementation. Laws are only as good as the ones that can be complied with. The Act is expected to deter people from breaking the law. However, there are serious problems due to poaching. One cannot expect to use the Act to reduce this without increasing Forest staff, providing weapons, jeeps, radio equipment, etc. for establishing a strong deterrent force.

Penalties: A person who breaks any of the conditions of any license or permit granted under this Act shall be guilty of an offence against this Act. The offence is punishable with imprisonment for a term which may extend to three years or with a fine of Rs 25,000 or with both. An offence committed in relation to any animal specified in Schedule I, or Part II of Schedule II, like the use of meat of any such animal, or animal articles like a trophy, shall be punishable with imprisonment for a term not less than one year and may extend to six years and a fine of Rs 25,000.

In the case of a second or subsequent offence of the same nature mentioned in this sub-section, the term of imprisonment may extend to

six years and not less than two years with a penalty of Rs.10,000.

What can an individual do?

- 1) If you observe an act of poaching, or see a poached animal, inform the local Forest Department Official at the highest possible level. One can also report the event through the press. Follow up to check that action is taken by the concerned authority. If no action is taken, one must take it up to the Chief Wildlife Warden of the State.
- 2) Say 'no' to the use of wildlife products and also try to convince other people not to buy them.
- 3) Reduce the use of wood and wood products wherever possible.
- 4) Avoid misuse of paper because it is made from bamboo and wood, which destroys wildlife habitat. Paper and envelopes can always be recycled.
- 5) Create a pressure group and ask Government to ensure that the biodiversity of our country is conserved.
- 6) Do not harm animals. Stop others from inflicting cruelty to animals.
- 7) Do not disturb birds nests and fledglings.
- 8) When you visit the Zoo do not tease the animals by throwing stones or feeding them, and prevent others from doing so.
- 9) If you come across an injured animal do what you can to help it.
- 10) If the animal needs medical care and expert attention contact the Society for the Prevention of Cruelty to Animals in your city.

3 to 4 billion, in 14 years.
4 to 5 billion, in 13 years.
5 to 6 billion, in 11 years.

It is not the census figures alone that need to be stressed, but an appreciation of the impact on natural resources of the rapid escalation in the rate of increase of human population in the recent past. The extent of this depletion is further increased by affluent societies that consume per capita more energy and resources, than less fortunate people. This is of great relevance for developing a new ethic for a more equitable distribution of resources.

In the first half of the 1900s human numbers were growing rapidly in most developing countries such as India and China. In some African countries the growth was also significant. In contrast, in the developed world population growth had slowed down. It was appreciated that the global growth rate was depleting the Earth's resources and was a direct impediment to human development. Several environmental ill-effects were linked with the increasing population of the developing world. Poverty alleviation programs failed, as whatever was done was never enough as more and more people had to be supported on Earth's limited resources. In rural areas population growth led to increased fragmentation of farm land and unemployment. In the urban sector it led to inadequate housing and an increasing level of air pollution from traffic, water pollution from sewage, and an inability to handle solid waste. By the 1970s most countries in the developing world had realized that if they had to develop their economics and improve the lives of their citizens they would have to curtail population growth.

Though population growth shows a general global decline, there are variations in the rate of decline in different countries. By the 1990s the growth rate was decreasing in most countries

such as China and India. The decline in the 90s was greatest in India. However, fertility continues to remain high in sub Saharan African countries.

There are cultural, economic, political and demographic reasons that explain the differences in the rate of population control in different countries. It also varies in different parts of certain countries and is linked with community and/or religious thinking. Lack of Government initiatives for Family Welfare Program and a limited access to a full range of contraceptive measures are serious impediments to limiting population growth in several countries.

7.2 POPULATION EXPLOSION – FAMILY WELFARE PROGRAM

In response to our phenomenal population growth, India seriously took up an effective Family Planning Program which was renamed the Family Welfare Program. Slogans such as *Hum do hamare do* indicated that each family should not have more than two children. It however, has taken several decades to become effective.

At the global level by the year 2000, 600 million, or 57% of women in the reproductive age group, were using some method of contraception. However the use of contraceptive measures is higher in developed countries – 68%, and lower in developing countries - 55%. Female sterilization is the most popular method of contraception used in developing countries at present. This is followed by the use of oral contraceptive pills and, intrauterine devices for women, and the use of condoms for men. India and China have been using permanent sterilization more effectively than many other countries in the developing world.

The best decision for the method used by a couple depends on a choice that they make for themselves. This must be based on good advice from doctors or trained social workers who can suggest the full range of methods available for them to choose from.

Informing the public about the various contraceptive measures that are available is of primary importance. This must be done actively by Government Agencies such as Health and Family Welfare, as well as Education and Extension workers. It is of great importance for policy makers and elected representatives of the people – Ministers, MPs, MLAs at Central and State levels – to understand the great and urgent need to support Family Welfare. The media must keep people informed about the need to limit family size and the ill effects of a growing population on the world's resources.

The decision to limit family size depends on a couple's background and education. This is related to Government Policy, the effectiveness of Family Welfare Programs, the educational level, and information level in mass communication. Frequent visits to Family Welfare information provided through the Health Care System, is in some cases unfortunately counteracted by cultural attitudes. Frequently misinformation and inadequate information are reasons why a family does not go in for limiting its size.

The greatest challenge the world now faces is how to supply its exploding human population with the resources it needs. It is evident that without controlling human numbers, the Earth's resources will be rapidly exhausted. In addition economically advanced countries and rich people in poorer countries use up more resources than they need.

As population expands further, water shortages will become acute. Soil will become unproduc-

tive. Rivers, lakes and coastal waters will be increasingly polluted. Water related diseases already kill 12 million people every year in the developing world. By 2025, there will be 48 countries that are starved for water. Air will become increasingly polluted. Air pollution already kills 3 million people every year.

The first 'green revolution' in the '60s produced a large amount of food but has led to several environmental problems. Now, a new green revolution is needed, to provide enough food for our growing population, that will not damage land, kill rivers by building large dams, or spread at the cost of critically important forests, grasslands and wetlands.

The world's most populous regions are in coastal areas. These are critical ecosystems and are being rapidly destroyed. Global climate change is now a threat that can affect the very survival of high population density coastal communities. In the sea, fish populations are suffering from excessive fishing. Once considered an inexhaustible resource, overfishing has depleted stocks extremely rapidly. It will be impossible to support further growth in coastal populations on existing fish reserves.

Human populations will inevitably expand from farm lands into the remaining adjacent forests. Many such encroachments in India have been regularised over the last few decades. But forest loss has long-term negative effects on water and air quality and the loss of biodiversity is still not generally seen as a major deterrent to human well-being. The extinction of plant and animal species resulting from shrinking habitats threatens to destroy the Earth's living web of life.

Energy use is growing, both due to an increasing population, and a more energy hungry lifestyle that increasingly uses consumer goods that require large amounts of energy for their

closely interlinked. An improvement in health is central to sound environmental management. However this is rarely given sufficient importance in planning development strategies.

Examples of the linkages:

- Millions of children die every year due to diarrhoea from contaminated water or food. An estimated 2000 million people are affected by these diseases and more than 3 million children die each year from water-borne diseases across the world. In India, it is estimated that every fifth child under the age of 5 dies due to diarrhoea. This is a result of inadequate environmental management and is mainly due to inadequate purification of drinking water. Wastewater and/or sewage entering water sources without being treated leads to continuous gastrointestinal diseases in the community and even sporadic large epidemics. Large numbers of people in tropical countries die of malaria every year and millions are infected. An inadequate environmental management of stagnant water, which forms breeding sites of Anopheles mosquitoes is the most important factor in the spread of malaria. The resurgence of malaria in India is leading to cerebral malaria that affects the brain and has a high mortality.
- Millions of people, mainly children, have poor health due to parasitic infections, such as amoebiasis and worms. This occurs from eating infected food, or using poor quality water for cooking food. It is estimated that 36% of children in low-income countries and 12% in middle income countries are malnourished. In India, about half the children under the age of four are malnourished and 30% of newborns are significantly underweight.
- Hundreds of millions of people suffer serious respiratory diseases, including lung cancer and tuberculosis, from crowded homes and public places. Motor vehicle exhaust fumes, industrial fumes, tobacco smoke and cooking food on improper 'chulas', contribute to respiratory diseases.
- Millions of people are exposed to hazardous chemicals in their workplace or homes that lead to ill health due to industrial products where controls are not adhered to.
- Tens of thousands of people in the world die due to traffic accidents due to inadequate management of traffic conditions. Poor management at the accident site, and inability to reach a hospital within an hour causes a large number of deaths, especially from head injuries.
- Basic environmental needs such as clean water, clean air and adequate nutrition which are all related to environmental goods and services, do not reach over 1000 million people living in abject poverty.
- Several million people live in inadequate shelters or have no roof over their heads especially in urban settings. This is related to high inequalities in the distribution of wealth and living space.
- Population growth and the way resources are being exploited and wasted, threatens environmental integrity and directly affects health of nearly every individual.
- Health is an outcome of the interactions between people and their environment. Better health can only come from a more sustainable management of the environment.

using fish to control mosquito larval populations, are ways to reduce these diseases without using toxic insecticides that have ill effects on human health.

4. Water scarcity diseases:

In areas where water and sanitation is poor, there is a high incidence of diseases such as tuberculosis, leprosy, tetanus, etc. which occur when hands are not adequately washed.

Arsenic in drinking water: Arsenic in drinking-water is a serious hazard to human health. It has attracted much attention since its recognition in the 1990s of its wide occurrence in well-water in Bangladesh. It occurs less frequently in most other countries. The main source of arsenic in drinking water is arsenic-rich rocks through which the water has filtered. It may also occur because of mining or industrial activity in some areas. WHO has worked with other UN organizations to produce a state-of-the-art review on arsenic in drinking water.

Drinking water that is rich in arsenic leads to arsenic poisoning or arsenicosis. Excessive concentrations are known to occur in some areas. The health effects are generally delayed and the most effective preventive measure is supplying drinking water which is free of arsenic. Arsenic contamination of water is also due to industrial processes such as those involved in mining, metal refining, and timber treatment. Malnutrition may aggravate the effects of arsenic on blood vessels.

Water with high concentrations of arsenic if used over 5 to 20 years, results in problems such as colour changes on the skin, hard patches on the palms and soles, skin cancer, cancers of the bladder, kidney and lung, and diseases of the blood vessels of the legs and feet. It may also lead to diabetes, high blood pressure and reproductive disorders.

Natural arsenic contamination occurs in Argentina, Bangladesh, Chile, China, India, Mexico, Thailand and the United States. In China (in the Province of Taiwan) exposure to arsenic leads to gangrene, known as 'black foot disease'.

Long term solutions for prevention of arsenicosis is based on providing safe drinking-water:

- Deeper wells are often less likely to be contaminated.
- Testing of water for levels of arsenic and informing users.
- Monitoring by health workers - people need to be checked for early signs of arsenicosis - usually by observing skin problems in areas where arsenic is known to occur.
- Health education regarding harmful effects of arsenicosis and how to avoid them.

CASE STUDIES

Arsenic poisoning – Bangladesh

More than half the population of Bangladesh is threatened by high levels of arsenic found in drinking water. This could eventually lead to an epidemic of cancers and other fatal diseases.

Rezaul Morol, a young Bangladeshi man, nearly died from arsenic poisoning caused by drinking arsenic-laden well-water for several years. The doctor advised Rezaul to stop drinking contaminated water and eat more protein-rich food such as fish. Since then Rezaul feels a lot better and is happy that his skin is healing.

Key measures to treat diarrhoea include:

- Giving more fluids than usual, (oral rehydration) with salt and sugar, to prevent dehydration.
- Continue feeding.
- Consulting a health worker if there are signs of dehydration or other problems.

In rural India, during the last decade public education through posters and other types of communication strategies has decreased infant mortality due to diarrhoea in several States. Posters depicting a child with diarrhoea being given water, salt and sugar solution to reduce death from dehydration has gone a long way in reducing both a serious condition requiring hospitalisation and intravenous fluids, as well as mortality.

7.3.5 Risks due to chemicals in food

Food contaminated by chemicals is a major worldwide public health concern. Contamination may occur through environmental pollution of the air, water and soil by chemicals, PCBs and dioxins, or the intentional use of various chemicals, such as pesticides, animal drugs and other agrochemicals have serious consequences on human health. Food additives and contaminants used during food manufacture and processing adversely affects health.

Diseases spread by food: Some foodborne diseases though well recognized, have recently become more common. For example, outbreaks of salmonellosis which have been reported for decades, has increased within the last 25 years. In the Western hemisphere and in Europe, *Salmonella* serotype Enteritidis (SE) has become a predominant strain. Investigations of SE outbreaks indicate that its emergence is largely related to consumption of poultry or eggs.

While cholera has devastated much of Asia and Africa for years, its reintroduction for the first time in almost a century on the South American continent in 1991 is an example of a well recognised infectious disease re-emerging in a region after decades. While cholera is often waterborne, many foods also transmit infection. In Latin America, ice and raw or underprocessed seafood are important causes for cholera transmission.

Infection with a specific type of *Escherichia coli* (E. coli) was first described in 1982. Subsequently, it has emerged rapidly as a major cause of bloody diarrhoea and acute renal failure. The infection is sometimes fatal, particularly in children. Outbreaks of infection, generally associated with beef, have been reported in Australia, Canada, Japan, United States, in various European countries, and in southern Africa. Outbreaks have also implicated alfalfa sprouts, unpasteurized fruit juice, lettuce, game meat (meat of wild animals) and cheese curd.

In 1996, an outbreak of *Escherichia coli* in Japan affected over 6,300 school children and resulted in 2 deaths.

Listeria monocytogenes (Lm): The role of food in the transmission of this condition has been recognized recently. In pregnant women, infections with Lm causes abortion and stillbirth. In infants and persons with a poor immune system it may lead to septicemia (blood poisoning) and meningitis. The disease is most often associated with consumption of foods such as soft cheese and processed meat products that are kept refrigerated for a long time, because Lm can grow at low temperatures. Outbreaks of listeriosis have been reported from many countries, including Australia, Switzerland, France and the United States. Two recent outbreaks of *Listeria monocytogenes* in France in 2000 and in the USA in 1999 were caused by contaminated pork tongue and hot dogs respectively.

ditional medicinal methods. Twenty-five percent of modern medicines are made from plants first used traditionally. Yoga is known to reduce asthma attacks. Traditional Medicine has been found to be effective against several infectious diseases.

CASE STUDY

A US company was granted a patent for discovering extracts of arhar (pigeon pea or *Cajanus cajan*) in the treatment of diabetes, hypoglycemia, obesity and blockage of arteries. The use of pigeon pea extracts in India is well known. CSIR has challenged this patent as it infringes on India's traditional knowledge, although challenging the patent is difficult, as India's scientific documentation of its traditional knowledge is quite poor.

Over one-third of the population in developing countries lack access to essential allopathic medicines. The provision of safe and effective TM/ CAM therapies could become a tool to increase access to health care.

7.5 VALUE EDUCATION

Value education in the context of our environment is expected to bring about a new sustainable way of life. Education both through formal and non-formal processes must thus address understanding environmental values, valuing nature and cultures, social justice, human heritage, equitable use of resources, managing common property resources and appreciating the cause of ecological degradation.

Essentially, environmental values cannot be taught. They are inculcated through a complex process of appreciating our environmental assets and experiencing the problems caused due

to our destruction of our environment. The problems that are created by technology and economic growth are a result of our improper thinking on what 'development' means. Since we still put a high value only on economic growth, we have no concern for aspects such as sustainability or equitable use of resources. This mindset must change before concepts such as sustainable development can be acted upon.

Unsustainable development is a part of economic growth of the powerful while it makes the poor poorer. Consumerism is one aspect of this process favoured by the rich. As consumption of resources has till recently been an index of development, consumerism has thrived. It is only recently that the world has come to realise that there are other more important environmental values that are essential to bring about a better way of life.

Values in environmental education must bring in several new concepts. Why and how can we use resources and energy? Why do we need to keep our surroundings clean? Why should we use less fertilisers and pesticides in farms? Why is it important for us to save water and keep our water sources clean? Or separate our garbage into degradable and non-degradable types before disposal? All these issues are linked to the quality of human life and go beyond simple economic growth. They deal with a love and respect for nature. These are the values that will bring about a better humanity, one in which we can live healthy, productive and happy lives in harmony with nature.

What are values?

Values deal with one's own principles and standards from which we judge what is right and wrong behaviour.

7.5.1 Environmental Values:

Every human being has a great variety of feelings for different aspects of his or her surroundings. The Western, modern approach values the resources of Nature for their utilitarian importance alone. However true environmental values go beyond valuing a river for its water, a forest for its timber and non-wood forest products, or the sea for its fish. Environmental values are inherent in feelings that bring about a sensitivity for preserving nature as a whole. This is a more spiritual, Eastern traditional value. There are several writings and sayings in Indian thought that support the concept of the oneness of all creation, of respecting and valuing all the different components of Nature. Our environmental values must translate to pro conservation actions in all our day to day activities. Most of our actions have adverse environmental impacts unless we consciously avoid them. The sentiment that attempts to reverse these trends is enshrined in our environmental values.

Values lead to a process of decision making which leads to action. For value education in relation to the environment, this process is carried through an understanding and appreciation of Nature's oneness and the importance of its conservation.

Humans have an inborn desire to explore Nature. Wanting to unravel its mysteries is a part of human nature. However, modern society and educational processes have invariably suppressed these innate sentiments. Once exposed to the wonders of the wilderness, people tend to bond closely to Nature. They begin to appreciate its complexity and fragility and this awakens a new desire to want to protect our natural heritage. This feeling for Nature is a part of our Constitution, which strongly emphasises this value.

Concepts of what constitutes right and wrong behaviour changes with time. Values are not constant. It was once considered 'sport' to shoot animals. It was considered a royal, brave and much desirable activity to kill a tiger. In today's context, with wildlife reduced to a tiny fraction of what there was in the past, it is now looked down upon as a crime against biodiversity conservation. Thus the value system has been altered with time. Similarly with the large tracts of forest that existed in the past, cutting a few trees was not a significant criminal act. Today this constitutes a major concern. We need a strong new environmental value system in which felling trees is considered unwise behaviour. With the small human numbers in the past, throwing away a little household degradable garbage could not have been considered wrong. But with enormous numbers of people throwing away large quantities of non-degradable waste, it is indeed extremely damaging to the environment and our value system must prevent this. We need a strong environmental value education system.

Appreciating the negative effects of our actions on the environment must become a part of our day to day thinking. Our current value system extols economic and technical progress as being what we need in our developing country.

Environmental values based on the Constitution of India

Article 48A:

"The state shall endeavour to protect and improve the environment and to safeguard the forests and wildlife in the country."

Article 51A (g)

The constitution expects that each citizen of the country must "protect and improve the natural environment, including forests, lakes, rivers and wildlife, and to have compassion for all living creatures."

agricultural experts, irrigation planners, mining experts, foresters, forest planners, industrialists and, most importantly, teachers at school and college level, are all closely related to pro environmental outcomes.

Environmental values have linkages to varied environmental concerns. While we value resources that we use as food, water and other products, there are also environmental services that we must appreciate. These include Nature's mechanisms in cleaning up air by removing carbon dioxide and adding oxygen by plant life, recycling water through the water cycle of nature, maintaining climate regimes, etc.

But there are other aesthetic, ethical values that are equally important aspects of our environment that we do not appreciate consciously. While every species is of importance in the web of life, there are some which man has come to admire for their beauty alone. The tiger's magnificence, the whale and elephant's giant size, the intelligence of our cousins the primates, the graceful flight of a flock of cranes, are part of nature that we cannot help but admire. The lush splendor of an evergreen forest, the great power of the ocean's waves, and the tranquility of the Himalayan mountains are among the best of us values even if we do not experience it ourselves. We value its being there on Earth for us. This is called its 'existence value'. The list of wondrous aspects of Nature's intricate connections is indeed awe-inspiring. This is also a part of our environment that we must value for its own sake. This is the oneness of Nature.

We must equally look at our environment beyond the wild sphere. There is incredible beauty in some man-modified landscapes, the coloured patterns of farmland or the greens of a tea or coffee plantation in the hills.

Urban gardens and open space are also valuable and thus must be of prime concern to urban planners. These green spaces act as not only

the lungs of a city, but also provide much needed psychological support. The mental peace and relaxation provided by such areas needs to be valued, although it is difficult to put a price tag on these values. Nevertheless, these centers of peace and tranquility give urban dwellers an opportunity to balance their highly man-modified environments with the splash of green of a garden space.

Environmental values must also stress on the importance of preserving ancient structures. The characteristic architecture, sculpture, artworks and crafts of ancient cultures is an invaluable environmental asset. It tells us where we have come from, where we are now, and perhaps where we should go. Architectural heritage goes beyond preserving old buildings, to conserving whole traditional landscapes in rural areas and streetscapes in urban settings. Unless we learn to value these landscapes, they will disappear and our heritage will be lost.

An environmentally conscious individuals we need to develop a sense of values that are linked with a better and more sustainable way of life for all people. There are several positive as well as negative aspects of behavior that are linked to our environment. The positive feelings that support environment include a value for Nature, cultures, heritage, and equity. We also need to become more sensitive to aspects that have negative impacts on the environment. These include our attitude towards degradation of the environment, loss of species, pollution, poverty, corruption in environmental management, the rights of future generations and animal rights.

Several great philosophers have thoughts that have been based on, or embedded, in pro environmental behavior. Mahatma Gandhi and Rabindranath Tagore are among the many internationally well-known scholars whose thought have included values that are related to environmental consciousness. We need to appreciate these values to bring about a better

8.1 VISIT TO A LOCAL AREA TO DOCUMENT ENVIRONMENTAL ASSETS RIVER/FOR- EST/GRASSLANDS/ HILL/MOUNTAIN

Background

Documenting the nature of an ecosystem gives us a deeper appreciation of its value to mankind. Each ecosystem has something different to offer us. It may contain natural resources that local people depend on; or provide important ecological functions for us all; or have tourist or recreational potential; or simply have a strong aesthetic appeal that is difficult to quantify in economic terms. In fact it can have multiple benefits for mankind at global, national and local levels. An ecosystem is not only used by different cultures and socio-economic groups in various ways, but has a different significance for different individuals depending on their way of life. A tribal from a wilderness setting, an agriculturalist from farmlands, a pastoralist from grasslands, or a fisherman looks on his or her environment very differently from an urban resident who is mainly focused on the management of the quality of air and water and the disposal of garbage. In many cultures, men and women will have different views and relationships with Nature. In rural India, for example, it is mostly women who collect resources and see the degradation of their ecosystem as a serious threat to the existence of their family and are thus more prone to fight against processes that lead to loss of their resource base.

Tribal people who live by hunting and gathering have a deep understanding of nature and what it provides for them to survive. Farmers know about cultivation of their land and water resources, and also appreciate what droughts and floods can do to their lives. A shepherd or livestock owner knows the grasslands intimately. In contrast, urban dwellers are far removed from the sites from where they get their natural resources. As these have originated from a prime area and have been collected by rural people, they cannot relate so easily to the value of protecting the ecosystems from which the resources have come.

In assessing an ecosystem's values it is not enough to look at its structure and functions, but at who uses it and how the resources reach the users. One also needs to appreciate what it means to oneself. The wilderness provides a sense of wonderment for all of us, if we experience it in person. This helps to bring about a desire to conserve natural resources.

Guidelines for the study of environmental assets:

There are two parts to this study:

1. Documenting what you see.
2. Documenting the findings of what you ask local user groups.

Proforma for fieldwork

Aims and objectives: To study the cause and effects of pollution at the site.

Methodology: Certain key questions related to the polluted site are given below. Explore the site to answer the questions about the area you have visited.

- What is the site?
Rural - agricultural area, polluted waterbody, polluted industrial area
Urban - Solid waste management site, Polluted industrial area
- What do you observe at the polluted site?
A solid waste- garbage dump, polluted water at a river or lake, gaseous effluents or smoke coming out of an industry area, etc.
- Explore the reasons for pollution. Observe and document the components in the garbage/ the polluted waterbody/ industrial chimneys.
- Observe the area and list the waste that is seen in the garbage dumping site. Categorise the waste into the three types:
 - Degradable wastes, are those which are easily decomposed by micro organisms. These include food wastes, plant material, animal carcasses, etc.
 - Non-degradable wastes are those which are not easily decomposed. Eg. plastic, glass.
 - Toxic wastes are those that are poisonous and cause long term effects. Eg. several chemicals, paints, spray, etc.

Findings:

- What are the effects of the pollutant?
- What actions can you take to get the pollution reduced?

2. Observing the Water Cycle:

During a monsoon field trip observe the effect of the rain.

- *The type of vegetation is an indicator of the amount of rainfall. Classify the ecosystem: forest / grassland/ semiarid/ desert type on the basis of rainfall.*
- *Observe how rain percolates into the subsoil. This recharges ground water, which charges wells, streams and rivers.*
- *Document if the rain is eroding the soil. This can be judged by observing if the water is brown in colour. The colour is an indicator of the extent of soil erosion and is darker wherever plant cover has been destroyed. It takes thousands of years for new soil to form. Excessive silt eventually changes the course of the river and leads to flooding of surrounding land.*

3. Observing the Carbon Cycle:

Since plants take up carbon dioxide, which we exhale, and split it into carbon and oxygen, which we breathe, we are dependent on the plant life on earth. Eventually large-scale deforestation could make life on earth impossible. Document this as an ecosystem service.

Carbon is a component of the food we eat in the form of carbohydrates, which come from plant material. Thus we need plants to give us oxygen and food, without which we cannot survive.

4. Observing the Oxygen Cycle:

While on the field trip focus attention on the amount of green material that plants contain. Without this there would not be enough oxygen for animals to breathe.

Sunlight is essential for plant photosynthesis, which produces new leaves, branches and the growth of the trunks of trees. It leads to growth of grass and herbs every year. Sunlight is essential for plant growth in the water, including microscopic algae and underwater vegetation which is the food producer for all aquatic forms of animal life.

5. Observing the Nitrogen Cycle:

Observe the quantity of dried leaves on the ground in a forest, or the dried leaves of plants planted in the area that have collected as detritus. This material can be seen to be decaying. Ants, beetles and worms that feed on this dead material are breaking it up into small fragments. Microscopic bacteria and fungi are acting on this material to convert it into nutrients for plants to grow.

- Understanding Prey and Predator relationships – Food chains:

There are spiders on the ground, which form tunnel webs to catch the crawling insects. In the trees wood spiders make giant webs three feet in diameter to catch flying insects. Look for the insect life in the canopy of the trees, on trunks, on the ground and especially under dead fallen leaves.

Identify which species are predators and what is their prey.

- Searching for examples of food chains, food webs and food pyramids:

Different species of lizards are found on the tree trunks and on the forest floor. There are chameleons in the trees and skinks on the ground. They are feeding on insect life, which in turn feed on the plants. This is a simple food chain that can be easily observed.

A spider catching an insect in its web is another demonstration of a simple food chain. The same insects are used by spiders and lizards as prey. Thus multiple food chains are linked to each other. This forms a small part of the food web of the forest.

There are several insectivorous birds such as bee eaters, fly catches of many species, babblers, etc. that form many different food chains.

There has to be a very large amount of plant life to provide enough food for the herbivores, which are prey species for the very few carnivores in the forest. This demonstrates how a food pyramid works and how energy moves from one level to the other. The energy is used for day to day functions of animals such as hunting for food, respiration, metabolising food and breeding. Observe that there is a very large amount of plant life, a smaller number of herbivores and very few carnivores. This observation explains the concept of the food pyramid.

- Document the linkages between food chains and processes such as pollination of plants in the forest:

Animals such as monkeys, squirrels and birds feed on leaves, fruits and seeds. Insects such as ants, butterflies and birds such as sunbirds and mynas use flower nectar for food. These flowers have bright colours to attract them. During this process the insects and birds pollinate the plants.

At night when most animals sleep, the bats and moths pollinate flowers. These flowers are usually white in colour so that they can be seen at night.

Thus many plants depend on animals to pollinate them so that seeds can develop. The regeneration of forests thus depends on these animals. These linkages are important aspects that maintain the forest's web of life.

Look for the pollinators – butterflies, moths, beetles, ants and nectar feeding birds are easy to observe.

Look for birds that eat berries and fruit and disperse seeds. These include bulbuls, parakeets.

Look for birds of prey that complete the food chain.