DIGITAL NOTES

ENVIRONMENTAL SCIENCE

(R18A0014)

B.Tech - II Year - II Semester

DEPARTMENT OF EEE

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

(An Autonomous Institution – UGC, Govt. of India)

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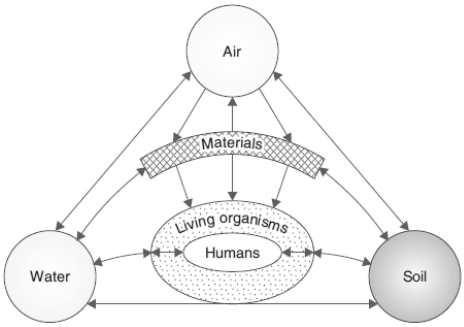
Unit 1: Ecosystems

Introduction

'**Environment**' is derived from the French word Environment which means to encircle or surround.

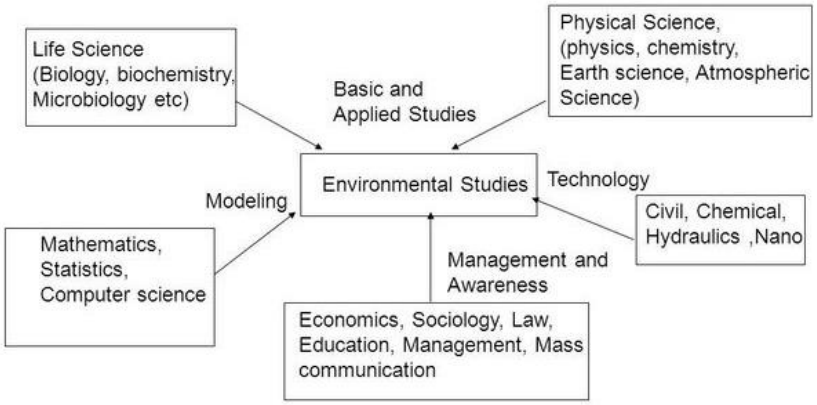
All the biological and non-biological things surrounding an organism are thus included in environment.

Environment is Thus defined as "the sum total of water, air and land, inter-relationships that exist among them and with the human beings, other living organisms and property".



Multidisciplinary nature of environmental studies

Thus, in order to study environment, one needs knowledge inputs from various disciplines.



- Life Sciences including Botany, Zoology, Microbiology, Genetics, Biochemistry and Biotechnology help in understanding the biotic component and their interactions.
- The physical and chemical structure of the abiotic components and energy transfer and flow are under-stood with the help of basic concepts of Physics, Chemistry, Geology, Atmospheric Science, Oceanography and Geography.
- Mathematics, Statistics and Computer Science serve as effective tools in environmental modelling and management.
- Subjects like Education, Economics, Sociology and Mass communication provide the inputs for dealing with the socio-economic aspects associated with various developmental activities.
- A synthesis with Environmental Engineering, Civil Engineering, Hydraulics and Chemical Engineering form the basis for various technologies dealing with the control of environmental pollution, waste-treatment and development of cleaner technologies that are important for protection of the environment.
- Environmental laws provide the tools for effective management and protection of the environment.

Environmental Studies, therefore, is a multidisciplinary subject where different aspects are deal with a holistic approach

Ecosystems:

The term Ecology was coined by Earnst Haeckel in 1869. It is derived from the Greek words Oikos- home + logos- study. So, ecology deals with the study of organisms in their natural home interacting with their surroundings. The surroundings or environment consists of other living organisms (biotic) and physical (abiotic) components. Modern ecologists believe that an adequate definition of ecology must specify some unit of study and one such basic unit described by Tansley (1935) was ecosystem. "An ecosystem is a group of biotic communities of species interacting with one another and with their non-living environment exchanging energy and matter". Now ecology is often defined as "the study of ecosystems".

An ecosystem is an integrated unit consisting of interacting plants, animals and microorganisms whose survival depends upon the maintenance and regulation of their biotic and abiotic structures and functions.

The ecosystem is thus, a unit or a system which is composed of a number of subunits, that are all directly or indirectly linked with each other. They may be freely exchanging energy and matter from outside—an open ecosystem or may be isolated from outside—a closed ecosystem

ECOSYSTEM CHARACTERISTICS

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

STRUCTURAL FEATURES

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

I.Biotic Structure

The plants, animals and microorganisms present in an ecosystem form the biotic component.

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

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

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

(i) Herbivores (plant eaters): They feed directly on producers and hence also known as primary consumers. e.g. rabbit, insect, man.

(ii) Carnivores (meat eaters): They feed on other consumers. If they feed on herbivores they are called secondary consumers (e.g. frog) and if they feed on other carnivores (snake, big fish etc.) they are known as tertiary carnivores/consumers.

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

(iv) Detritivores (Detritus feeders or Saprotrophs): They feed on the parts of dead organisms, wastes of living organisms, their cast-offs and partially decomposed matter e.g. beetles, termites, ants, crabs, earthworms etc.

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

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

II. Abiotic Structure

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

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

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

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

FUNCTIONAL FEATURES

Every ecosystem performs under natural conditions in a systematic way. It receives energy from the sun and passes it on through various biotic components and in fact, all life depends upon this flow of energy.

The major functional attributes of an ecosystems are as follows:

(i) Food chain, food webs and trophic structure.

(ii) Energy flow.

(iii) Cycling of nutrients (Biogeochemical cycles).

(iv) Primary and Secondary production.

(v) Ecosystem development and regulation.

Tropic structure: The structure and functions of the ecosystem are interrelated and influence each other. The flow of energy is mediated through a series of feeding relation ships in a definite sequence or pattern which is known as Food chain. Nutrients too move along the food chain. The producers and consumers are arranged in an ecosystem in a definite manner and their interaction along with the population size is expressed together as Trophic structure. Each food level is known as Trophic level and the amount of living matter at each Trophic level at a given time is known as **standing crop or standing biomass.**

(i) FOOD CHAINS

- **The sequence of eating and being eaten in an ecosystem** is known as food chain.
- All organisms, living or dead, are potential food for some other organism and thus, there is essentially no waste in the functioning of a natural ecosystem.

Some common examples of simple food chains are:

Grass → grasshopper → Frog → Snake → Hawk (Grassland ecosystem)

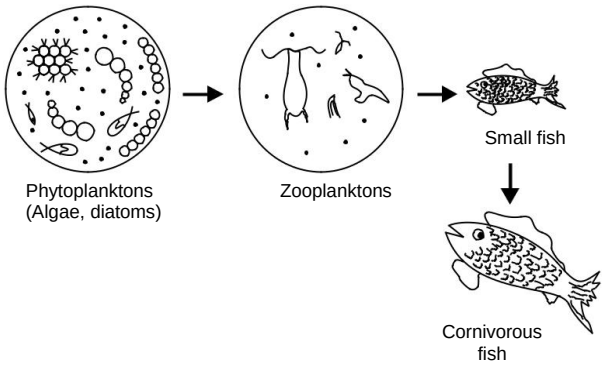
Phytoplankton's → water fleas → small fish → Tuna (Pond ecosystem)

Each organism in the ecosystem is assigned a feeding level or trophic level depending on its nutritional status. Thus, in the grassland food chain, grasshopper occupies the Ist trophic level, frog the IInd and snake and hawk occupy the IIIrd and the IVth trophic levels, respectively.

The decomposers consume the dead matter of all these trophic levels. In nature, we come across two major types of food chains.

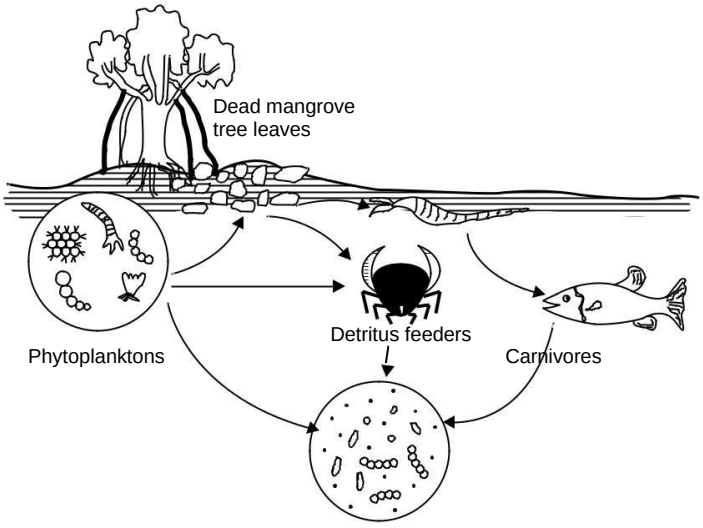
1. Grazing food chain: It **starts with green plants** (primary producers) and culminates in carnivores. All the examples cited above show this type of food chain. Another example could be

Grass → Rabbit → Fox



A grazing food chain in a pond ecosystem

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



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

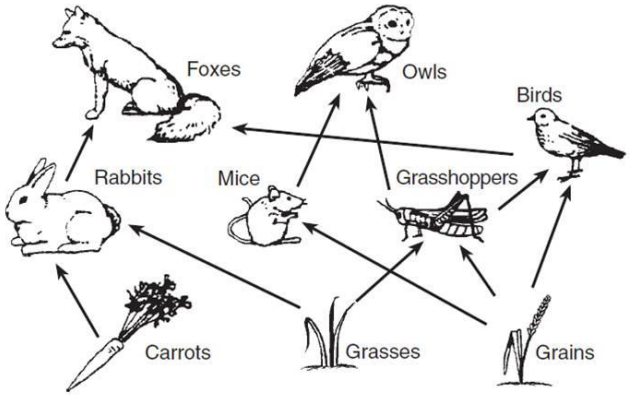
Leaf litter → algae → crabs → small carnivorous fish → large carnivorous fish (Mangrove ecosystem)

Dead organic matter → fungi → bacteria (Forest ecosystem)

FOOD WEB

Food chains in ecosystems are rarely found to operate as isolated linear sequences. Rather, they are found to be interconnected and usually form a complex network with several

linkages and are known as food webs. Thus, "food web is **a network of food chains** where different types of organisms are connected at different trophic levels, so that there are a number of options of eating and being eaten at each trophic level."



(Not drawn to scale)

Significance of food chains and food webs

Food chains and food webs play a very significant role in the ecosystem because the two most important functions of energy flow and nutrient cycling take place through them.

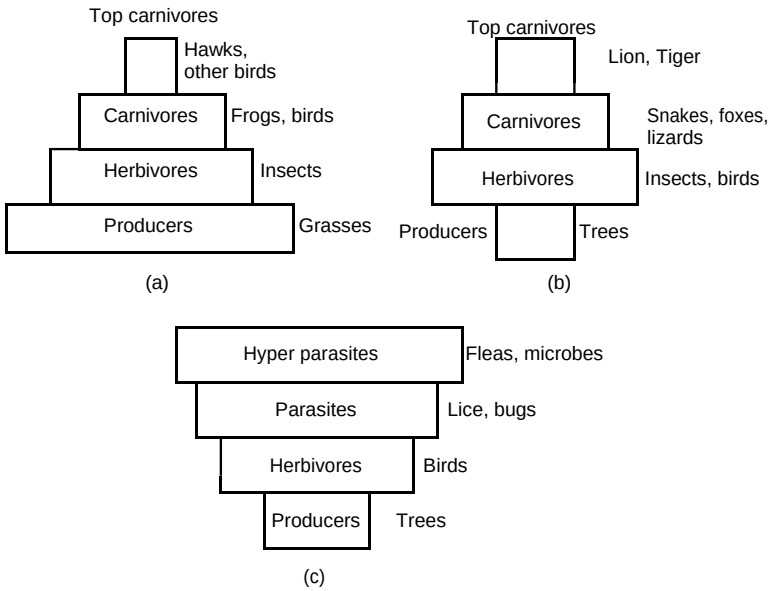
- The food chains also help in maintaining and regulating the population size of different animals and thus, help maintain the ecological balance.
- Food chains show a unique property of biological magnification of some chemicals.

ECOLOGICAL PYRAMIDS

Graphic representation of tropic structure and function of an ecosystem, starting with producers at the base and successive trophic levels forming the apex is knows as an ecological pyramid.

Ecological pyramids are of three types:

a) Pyramid of numbers: It represents the number of individual organisms at each trophic level. We may have upright or inverted pyramid of numbers, depending upon the type of ecosystem and food chain as shown in below Fig.

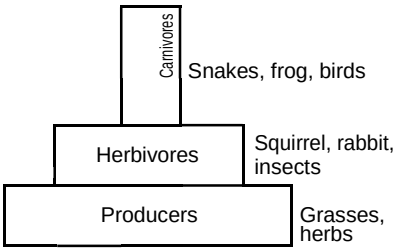


- A grassland ecosystem (Fig. a) and a pond ecosystem show an upright pyramid of numbers. The producers in the grasslands are grasses and that in a pond are phyto planktons (algae etc.), which are small in size and very large in number. So the producers form a broad base. The herbivores in a grassland are insects while tertiary

carnivores are hawks or other birds which are gradually less and less in number and hence the pyramid apex becomes gradually narrower forming an upright pyramid.

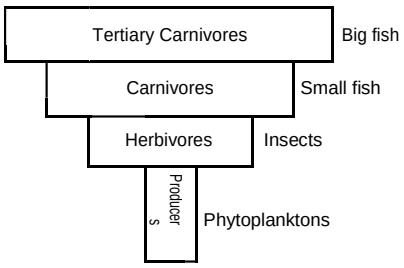
- In a forest ecosystem (Fig. b), big trees are the producers, which are less in number and hence form a narrow base. A larger number of herbivores including birds, insects and several species of animals feed upon the trees (on leaves, fruits, flowers, bark etc.) and form a much broader middle level. The secondary consumers like fox, snakes, lizards etc. are less in number than herbivores while top carnivores like lion, tiger etc. are still smaller in number. So the pyramid is narrow on both sides and broader in the middle.
- Parasitic food chain shows (Fig. c) an inverted pyramid of number. The producers like a few big trees harbour fruit eating birds acting like herbivores which are larger in number. A much higher number of lice, bugs etc. grow as parasites on these birds while a still greater number of hyper parasites like bugs, fleas and microbes feed upon them, thus making an inverted pyramid.

b) Pyramid of biomass: It is based upon the total biomass (dry matter) at each trophic level in a food chain. The pyramid of biomass can also be upright or inverted.



(a)

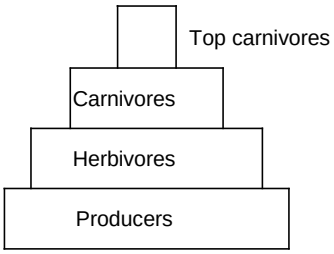
above Fig. (a, b) shows pyramids of biomass in a forest and an aquatic ecosystem. The pyramid of biomass in a forest is upright in contrast to its pyramid of numbers. This is because the producers (trees) accumulate a huge biomass while the consumers' total biomass feeding on them declines at higher trophic levels, resulting in broad base and narrowing top.



(b)

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

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



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

Unit 2: Natural Resources

Life on this planet earth depends upon a variety of goods and services provided by the nature, which are known as Natural resources. Thus water, air, soil, minerals, coal, forests, crops and wildlife are all examples of natural resources. Any stock or reserve that can be drawn from nature is a Natural resources .

CLASSIFICATION OF RESOURCES

Resources can be classified in the following ways:

(A) Living and non-living resources

Living resources are biological resources that are used by human beings e.g. forests, croplands, animal resources.

Non-living resources are not derived from biological materials e.g. soil, land, water.

(B) Renewable and non-renewable resources

Renewable resources which are in exhaustive and can be regenerated within a given span of time e.g. forests, wildlife, wind energy, biomass energy, tidal energy, hydro power etc. Solar energy is also a renewable form of energy as it is an inexhaustible source of energy.

Non-renewable resources which cannot be regenerated in a time span e.g. Fossil fuels like coal, petroleum, minerals etc. Once we exhaust these reserves, the same cannot be replenished. Even our renewable resources can become non-renewable if we exploit them to such extent that their rate of consumption exceeds their rate of regeneration. For example, if a species is exploited so much that its population size declines below the threshold level then it is not able to sustain itself and gradually the species becomes endangered or extinct.

It is very important to protect and conserve our natural resources and use them in a judicious manner so that we do not exhaust them. Itdoes not mean that we should stop using most of the natural resources. Rather, we should use the resources in such a way that we always save enough of them for our future generations.

WATER RESOURCES

Water is an indispensable natural resource on this earth on which. all life depends. About 97% of the earth's surface is covered by water and most of the animals and plants have 60-65% water in their body.

Water-A Unique Resource

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

i. It exists as a liquid over a wide range of temperature i.e. from 0° to 100°C.
ii. It has the highest specific heat, due to which it warms up and cools down very slowly without causing shocks of temperature jerks to the aquatic life.
iii. It has a high latent heat of vaporization. Hence, it takes a huge amount of energy for getting vaporized. That's why it produces a cooling effect as it evaporates.
iv. It is an excellent solvent for several nutrients. Thus, it can serve as a very good carrier of nutrients, including oxygen, which are essential for life. But, it can also easily dissolve various pollutants and become a carrier of pathogenic microorganisms.
v. Due to high surface tension and cohesion it can easily rise through great heights through the trunk even in the tallest of the trees like *Sequoia.*
vi. It has an anomalous expansion behavior i.e. as it freezes, it expands instead of contracting and thus becomes lighter. It is because of this property that even in extreme cold, the lakes freeze only on the surface. Being lighter the ice keeps floating, whereas the bottom waters remain at a higher temperature and therefore, can sustain aquatic organisms even in extreme cold.

DAMS- BENEFITS AND PROBLEMS

Big dams are often regarded as a symbol of national development. However, there are several other issues and problems related to these. Fig. 2.2 depicts various aspects associated with big dams.

BENEFITS OF DAMS

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

ENVIRONMENTAL PROBLEMS DUE TO DAMS

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

(A) The upstream problems include the following:

(i) Displacement of tribal people
(ii) Loss of forests, flora and fauna
(iii) Changes in fisheries and the spawning grounds
(iv) Siltation and sedimentation of reservoirs
(v) Loss of non-forest land
(vi) Stagnation and waterlogging near reservoir
(vii) Breeding of vectors and spread of vector-borne diseases
(viii) Reservoir induced seismicity (RIS) causing earthquakes
(ix) Growth of aquatic weeds.
(x) Microclimatic changes.

(B) The downstream impacts include the following:

(i) Water logging and salinity due to over irrigation
(ii) Micro-climatic changes
(iii) Reduced water flow and silt deposition in river
(iv) Flash floods
(v)Salt water intrusion at river mouth
(vi) Loss of land fertility along the river since the sediments carrying nutrients get deposited in the reservoir
(vii) Outbreak of vector-borne diseases like malaria

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

FOREST RESOURCES

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

About 1/3rd of the world's land area is forested which includes closed as well as open forests.

Uses of Forests

Commercial uses: Forests provide us a large number of commercial goods which include timber, firewood, pulpwood, food items, gum, resins, non-edible oils, rubber, fibers, lac,

bamboo canes, fodder, medicine, drugs and many more items.

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

Ecological uses: While a typical tree produces commercial goods worth about $ 590 it provides environmental services worth nearly $ 196, 250.

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

Production of oxygen: The trees produce oxygen by photo-synthesis which is so vital for life on this earth. They are rightly called as earth's lungs.

Reducing global warming: The main greenhouse gas car-bon dioxide (CO_2) is absorbed by the forests as a raw material for photosynthesis. Thus forest canopy acts as a sink for CO_2 thereby reducing the problem of global warming caused by greenhouse gas CO_2

Wild life habitat: Forests are the homes of millions of wild animals and plants. About 7 million species are found in the tropical forests alone.

Regulation of hydrological cycle: Forested watersheds act like giant sponges, absorbing the rainfall, slowing down the runoff and slowly releasing the water for recharge of springs. About 50-80 %of the moisture in the air above tropical forests comes from their transpiration which helps in bringing rains.

Soil Conservation: Forests bind the soil particles tightly in their roots and prevent soil erosion. They also act as wind-breaks.

Pollution moderators: Forests can absorb many toxic gases and can help in keeping the air pure. They have also been reported to absorb noise and thus help in preventing air and noise pollution.

DEFORESTATION

Deforestation is the permanent destruction of forests in order to make the land available for other uses. Some other statistics

Major Causes of Deforestation

(i) Shifting cultivation: There are an estimated 300 million people living as shifting cultivators who practice slash and burn agriculture and are supposed to clear more than 5 lakh ha of forests for shifting cultivation annually. In India, we have this practice in North-East and to some extent in Andhra Pradesh, Bihar and M.P which contribute to nearly half of the forest clearing annually.

(ii) Fuel requirements: Increasing demands for fuel wood by the growing population in India alone has shooted up to 300-500 million tons in 2001 as compared to just 65 million tons during independence, thereby increasing the pressure on forests.

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

(iv) Development projects: Massive destruction of forests occur for various development projects like hydroelectric projects, big dams, road construction, mining etc.

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

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

Major Consequences of Deforestation

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

(i) It threatens the existence of many wild life species due to destruction of their natural habitat

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

(iii) Hydrological cycle gets affected, thereby influencing rainfall.
(iv) Problems of soil erosion and loss of soil fertility increase.
(v) In hilly areas it often leads to landslides

ENERGY RESOURCES

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

The first form of energy technology probably was the fire, which produced heat and the early man used it for cooking and heating purposes. Wind and hydropower have also been in use for the last 10,000 years. The invention of steam engines replaced the burning of wood by coal and coal was later replaced to a great extent by oi1. In 1970's due to Iranian revolution and Arab oil embargo the prices of oil shot up. This ultimately led to exploration and use of several alternate sources of energy.

RENEWABLE AND NON-RENEWABLE ENERGY SOURCES

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

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

(2) Non-renewable resources which have accumulated in nature over a long span of time and cannot be quickly replenished when exhausted e.g. coal, petroleum, natural gas and nuclear fuels like uranium and thorium.

Wood is a renewable resource as we can get new wood by growing a sapling into a tree within 15-20 years but it has taken millions of years for the formation of coal from trees and cannot be regenerated in Our life time, hence coal is not renewable. We will now discuss various forms of renewable and non-renewable energy resource.

Renewable Energy Resources (Alternate Energy Resource)

Solar Energy: Sun is the ultimate source of energy, directly or indirectly for all other forms of energy. The nuclear fusion reactions occurring inside the sun release enormous quantities of energy in the form of heat and light. The solar energy received by the near earth space is approximately 1.4 kilojoules/ second/ m2 known as solar constant.

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

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

(ii) **Solar cells:** They are also known as photovoltaic cells or PV cells. Solar cells are made of thin wafers of semi-conductor materials like silicon and gallium. When solar radiations fall on them, a potential difference is produced which causes flow of electrons and produces electricity. Silicon can be obtained from silica or sand, which is abundantly available and inexpensive. By using gallium arsenide, cadmium supplied or boron, efficiency of the PV cells can be improved. The potential difference produced by a single PV cell of 4 ern- size is about 0.4-0.5 volts and produces a current of 60 milli amperes

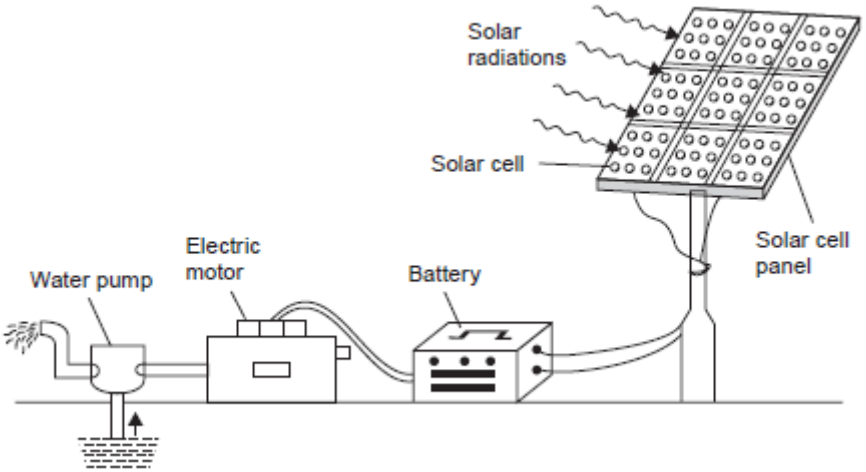


FIG 1 A solar pump run by electricity produced by solar cells.

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

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

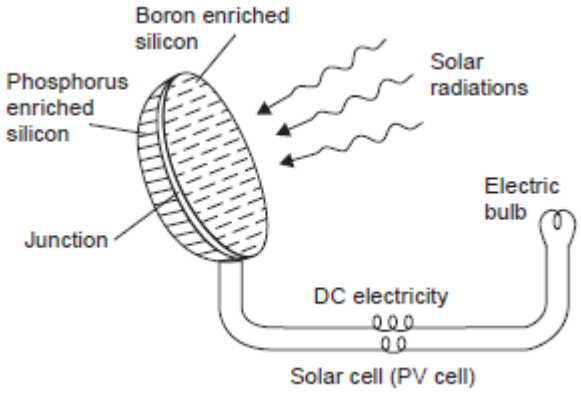


Fig 2 Solar cell.

(iii) **Solar cooker*:*** *Solar cookers make use of solar heat by reflecting* the solar radiations using a mirror directly on to a glass sheet which covers the black insulated box within which the raw food is kept. A new design of solar cooker is now available which involves a spherical reflector (concave or parabolic reflector) instead of plane mirror that has more heating effect and hence greater efficiency.

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

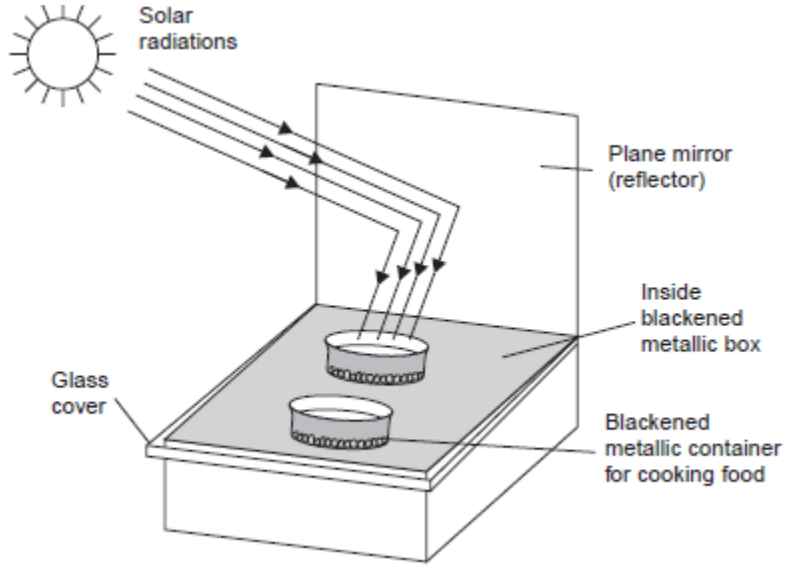


FIG 3 Simple box-type solar cooker.

Wind energy: The high speed winds have a lot of energy in them as kinetic energy due to their motion. The driving force of the winds is the sun. The wind energy is harnessed by making use of wind mills. The blades of the wind mill keep on rotating continuously due to the force of the striking wind. The rotational motion of the blades drives a number of machines like water pumps, flour mills and electric generators. A large number of wind mills are installed in clusters called wind farms, which feed power to the utility grid and produce a large amount of electricity. These farms are ideally located in coastal regions, open grasslands or hilly regions, particularly mountain passes and ridges where the winds are strong and steady. *The minimum wind speed required for satisfactory working of a wind generator is* 15 *km / hr. Natural Resources*

The wind power potential of our country is estimated to be about 20,000 MW, while at present we are generating about 1020 MW. The largest wind farm of our country is near Kanyakumari in Tamil Nadu generating 380 MW electricity.

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

Hydro power: The water flowing in a river is collected by constructing a big dam where the water is stored and allowed to fall from a height. The blades of the turbine located at the bottom of the dam move with the fast moving water which in turn rotate the generator and produces electricity. We can also construct mini or micro hydel power plants on the rivers in hilly regions for harnessing the hydro energy on a small scale, but the minimum height of the waterfalls should be 10 meters. The hydropower potential of India is estimated to be about 4 x $l0^{ll}$ KW-hours. Till now we have utilized only a little more than 11% of this potential.

Hydropower does not cause any pollution, it is renewable and normally the hydro power projects are multipurpose projects helping in controlling floods, used for irrigation, navigation etc. However, big dams are often associated with a number of environmental impacts .

Tidal energy: Ocean tides produced by gravitational forces of sun and moon contain enormous amounts of energy. The **'high tide'** and **'low tide'** refer to the rise and fall of water in the oceans. A difference of several meters is required between the height of high and low tide to spin the turbines. The tidal energy can be harnessed by constructing a tidal barrage.

During high tide, the sea-water flows into the reservoir of the barrage and turns the turbine, which in turn produces electricity by rotating the generators. During low tide, when the sea-level is low, the sea water stored in the barrage reservoir flows out into the sea and again turns the turbines.

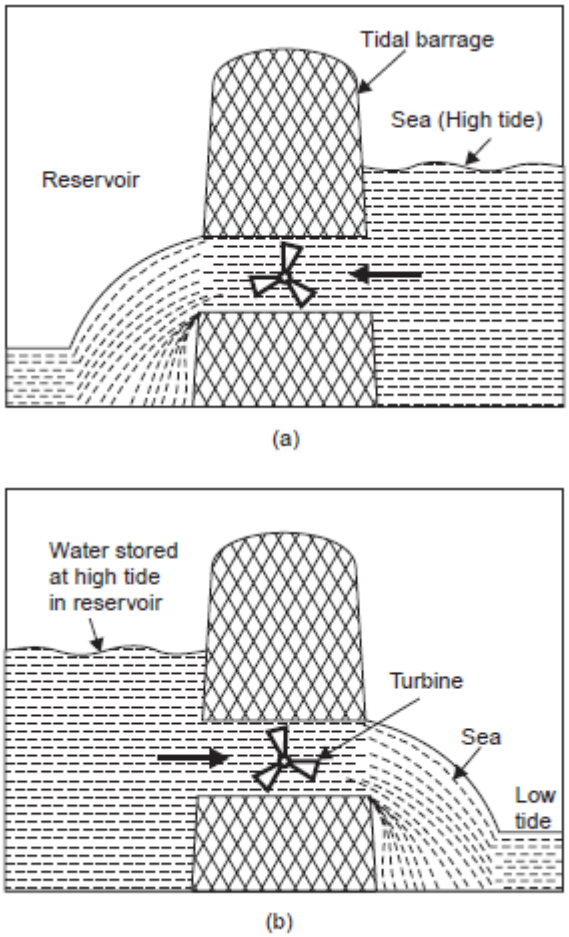


FIG 5 Water flows into the reservoir to turn the turbine at high tide (*a*), and flows out from the reservoir to the sea, again turning the turbine at low tide (*b*).

There are only a few sites in the world where tidal energy can be suitably harnessed. The Bay of Fundy, Canada having 17-18 m high tides has a potential of 5,000 MW of power generation. The tidal mill at La Rance, France is one of the first modern tidal power mill. In India, Gulf of Cambay, Gulf of Kutch and the Sunder ban deltas are the tidal power sites.

Non Renewable Energy Sources

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

Coal : Coal was formed 255-350 million years ago in the hot, damp regions of the earth during the carboniferous age. The ancient plants along the banks of rivers and swamps were buried after death into the soil and due to the heat and pressure gradually got converted into peat and coal over millions of years of time. There are mainly three types of coal, namely *anthracite* (hard coal), *bituminous* (soft coal) and *lignite* (brown coal). Anthracite coal has maximum carbon (90%) and calorific value (8700 kcallkg.) Bituminous, lignite and peat

contain 80, 70 and 60% carbon, respectively. Coal is the most abundant fossil fuel in the world. *At the present rate of usage, the coal reserves are likely to last for about 200 years and if its use increases by* 2% *per year, then it will last for another* 65 *years.*

India has about 5% of world's coal and Indian coal is not very good in terms of heat capacity. Major coal fields in India are Raniganj, Jharia, Bokaro, Singrauli, and Godavari valley. The coal states of India are Jharkhand, Orissa, West Bengal, Madhya Pradesh, Andhra Pradesh and Maharashtra. Anthracite coal occurs only in J & K.

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

Petroleum: It is the lifeline of global economy. There are 13 countries in the world having 67% of the petroleum reserves which together form the OPEC (Organization of Petroleum Exporting Countries). About 1I4th of the oil reserves are in Saudi Arabia.

At the present rate of usage, the world's crude oil reserves are estimated to get exhausted in just 40 years. Some optimists, however, believe that there are some yet undiscovered reserves. Even then the crude oil

reserves will last for another 40 years or so. Crude petroleum is a complex mixture of alkane hydrocarbons. Hence it has to be purified and refined by the process of fractional distillation, during which process different constituents separate out at different temperatures. We get a large variety of products from this, namely, petroleum gas, kerosene, petrol, diesel, fuel oil, lubricating oil, paraffin wax, asphalt, plastic etc.

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

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

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

Natural Gas: It is mainly composed of methane (95%) with small amounts of propane and ethane. It is a fossil fuel. Natural gas deposits mostly accompany oil deposits because it has been formed by decomposing remains of dead animals and plants buried under the earth. Natural gas is the cleanest fossil fuel. It can be easily transported through pipelines. It has a high calorific value of about 50KJ/G and burns without any smoke.

Currently, the amount of natural gas deposits in the world are of the order of 80, 450 g m ". Russia has maximum reserves (40%), followed by Iran (14%) and USA (7%). Natural gas reserves are found in association with all the oil fields in India. Some new gas fields have been found in Tripura, Jaisalmer, off-shore area of Mumbai and the Krishna-Godavari Delta.

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

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

Unit 3: Environmental Pollution

For normal and healthy living a conducive environment is required by all the living beings, including humans, livestock, plants, microorganisms and the wildlife.
The favourable unpolluted environment has a specific composition. When this composition gets changed by addition of harmful substances, the environment is called polluted environment and the substances polluting it are called pollutants.

Environmental pollution can, therefore, be defined as any undesirable change in the physical, chemical or biological characteristics of any component of the environment (air, water, soil), which can cause harmful effects on various forms of life or property.
Environmental pollution could be of various types

AIR POLLUTION

Air pollution can, therefore, be defined as any undesirable change in the physical, chemical or biological characteristics of air, which can cause harmful effects on various forms of life or property.

It is an atmospheric condition in which certain substances (including the normal constituents in excess) are present in concentrations which can cause undesirable effects on man and his environment. These sub-stances include gases, particulate matter, radioactive substances etc.

- Gaseous pollutants include oxides of sulphur (mostly SO2, SO3) oxides of nitrogen (mostly NO and NO2 or NOx), carbon monoxide (CO), volatile organic compounds (mostly hydrocarbons) etc.
- Particulate pollutants include smoke, dust, soot, fumes, aerosols, liquid droplets, pollen grains etc.
- Radioactive pollutants include radon-222, iodine-131, strontium-90, plutonium-239 etc.

Sources of Air Pollution

The sources of air pollution are natural and man-made (anthropogenic).
Natural Sources: The natural sources of air pollution are volcanic eruptions, forest fires, sea salt sprays, biological decay, photochemical oxidation of terpenes, marshes, extra terrestrial bodies, pollen grains of flowers, spores etc. Radioactive minerals present in the earth crust are the sources of radioactivity in the atmosphere
Man-made sources: Man made sources include thermal power plants, industrial units, vehicular emissions, fossil fuel burning, agricultural activities etc. Thermal power plants have become the major sources for generating electricity in India as the nuclear power plants couldn't be installed as planned. The main pollutants emitted are fly ash and SO2. Metallurgical plants also consume coal and produce similar pollutants. Fertilizer plants, smelters, textile mills, tanneries, refineries, chemical industries, paper and pulp mills are other sources of air pollution.
Automobile exhaust is another major source of air pollution. Automobiles release gases such as carbon monoxide (about 77%), oxides of nitrogen (about 8%) and hydrocarbons (about 14%). Heavy duty diesel vehicles spew more NOx and suspended particulate matter (SPM) than petrol vehicles which produce more carbon monoxide and hydrocarbons.
Classification: On the basis of origin of pollutants
a)Primary pollutants : These are emitted directly from the point sources . Ex: Smoke, dust…etc.
b) Secondary pollutants : These are formed by interaction of primary pollutants with other primary pollutants (or) primary pollutants with natural constituents of atmosphere. Ex: Smog, PAN
Effects of air pollution: Air pollution has adverse effects on living organisms and materials

Effects on Human Health:

- Human respiratory system has a number of mechanisms for protection from air pollution. Bigger particles (> 10 μm) can be trapped by the hairs and sticky mucus in the lining of the nose. Smaller particles can reach tracheobronchial system and there get trapped in mucus.
- They are sent back to throat by beating of hair like cilia from where they can be removed by spitting or swallowing. Years of exposure to air pollutants (including cigarette smoke) adversely affect these natural defences and can result in lung cancer, asthma, chronic bronchitis and emphysema (damage to air sacs leading to loss of lung elasticity and acute shortness of breath).
- Suspended particulates can cause damage to lung tissues and diseases like asthma, bronchitis and cancer especially when they bring with them cancer causing or toxic pollutants attached on their surface.
- Sulphur dioxide (SO_2) causes constriction of respiratory passage and can cause bronchitis like conditions.
- In the presence of suspended particulates, SO_2 can form acid sulphate particles, which can go deep into the lungs and affect them severely.
    - Oxides of nitrogen especially NO_2 can irritate the lungs and cause conditions like chronic bronchitis and emphysema.
    - Carbon monoxide (CO) reaches lungs and combines with haemoglobin of blood to form carboxyhaemoglobin. CO has affinity for haemoglobin 210 times more than oxygen. Haemoglobin is, therefore, unable to transport oxygen to various parts of the body. This causes suffocation. Long exposure to CO may cause dizziness, unconsciousness and even death.
    - Many other air pollutants like benzene (from unleaded petrol), formaldehyde and particulates like polychlorinated biphenyls (PCBs) toxic metals and dioxins (from burning of polythene) can cause mutations, reproductive problems or even cancer.
    - Hazardous materials like Asbestos, Mercury, Arsenic and radioactive materials cause lung diseases and effect to other organs like brain, kidney, liver, heart….etc

Effects on Plants:

- Air pollutants affect plants by entering through stomata (leaf pores through which gases diffuse), destroy chlorophyll and affect photosynthesis.
- Pollutants also erode waxy coating of the leaves called cuticle.
- Cuticle prevents excessive water loss and damage from diseases, pests, drought and frost.
- Damage to leaf structure causes necrosis (dead areas of leaf), chlorosis (loss or reduction of chlorophyll causing yellowing of leaf) or epinasty (downward curling of leaf), and abscission (dropping of leaves). Particulates deposited on leaves can form encrustations and plug the stomata. The damage can result in death of the plant.

Effects on aquatic life:

- Air pollutants mixing up with rain can cause high acidity (lower pH) in fresh water lakes.
- This affects aquatic life especially fish. Some of the freshwater lakes have experienced total fish death.

Control of Air pollution

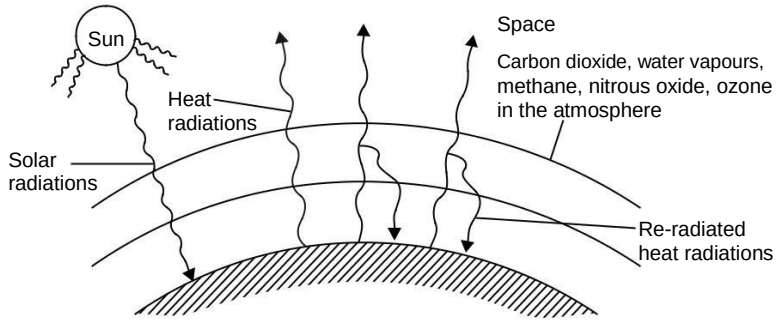
Air pollution can be minimized by the following methods:

- Use non-conventional sources.
- Shifting to less polluting fuels.
- Planting more trees.
- Use transport system like bicycle…etc.
- Using low sulphur coal in industries.

- Minimize activities which cause pollution like transportation and energy production.
- Reduction of pollution at sources.

Global Warming

- Troposphere, the lowermost layer of the atmosphere, traps heat by a natural process due to the presence of certain gases. This effect is called Green House Effect as it is similar to the warming effect observed in the horticultural greenhouse made of glass.
- The amount of heat trapped in the atmosphere depends mostly on the concentrations of "heat trapping" or "greenhouse" gases and the length of time they stay in the atmosphere. The major greenhouse gases are carbon dioxide, ozone, methane, nitrous oxide, chlorofluorocarbons (CFCs) and water vapours.
- Heat trapped by greenhouse gases in the atmosphere keeps the planet warm is called global warming.



Greenhouse Effect

The enhanced greenhouse effect will not only cause global warming but will also affect various other climatic and natural processes.

(i) **Global temperature increase**: It is estimated that the earth's mean temperature will rise between 1.5 to 5.5°C by 2050 if input of greenhouse gases continues to rise at the present rate. Even at the lower value, earth would be warmer than it has been for 10,000 years.

(ii) **Rise in Sea Level:** With the increase in global temperature sea water will expand. Heating will melt the polar ice sheets and glaciers resulting in further rise in sea level. Current models indicate that an increase in the average atmospheric temperature of 3°C would raise the average global sea level by 0.2–1.5 meters over the next 50–100 years.

One meter rise in sea level will inundate low lying areas of cities like Shanghai, Cairo, Bangkok, Sydney, Hamburg and Venice as well as agricultural lowlands and deltas in Egypt, Bangladesh, India, China and will affect rice productivity. This will also disturb many commercially important spawning grounds, and would probably increase the frequency of storm damage to lagoons, estuaries and coral reefs.

In India, the Lakshadweep Islands with a maximum height of 4 meters above the level may be vulnerable. Some of the most beautiful cities like Mumbai may be saved by heavy investment on embankment to prevent inundation.

Life of millions of people will be affected, by the sea level rise who have built homes in the deltas of the Ganges, the Nile, the Mekong, the Yangtze and the Mississippi rivers.

(iii) **Effects on Human Health:** The global warming will lead to changes in the rainfall pattern in many areas, thereby affecting the distribution of vector-borne diseases like malaria, filariasis, elephantiasis etc.

Areas which are presently free from diseases like malaria, schistosomiasis etc. may become the breeding grounds for the vectors of such diseases. The areas likely to be affected in this manner are Ethiopia, Kenya and Indonesia. Warmer temperature and more water stagnation would favour the breeding of mosquitoes, snails and some insects, which are the vectors of such diseases.

Higher temperature and humidity will increase/aggravate respiratory and skin diseases.

(iv) **Effects on Agriculture:** There are different views regarding the effect of global warming on agriculture. It may show positive or negative effects on various types of crops in different regions of the world. Tropical and subtropical regions will be more affected since the average temperature in these regions is already on the higher side. Even a rise of 2°C may be quite harmful to crops. Soil moisture will decrease and evapotranspiration will increase, which may drastically affect wheat and maize production.

Increase in temperature and humidity will increase pest growth like the growth of vectors for various diseases. Pests will adapt to such changes better than the crops.

To cope up with the changing situation drought resistant, heat resistant and pest resistant varieties of crops have to be developed.

Ozone Layer Depletion

For the last 450 million years the earth has had a natural sunscreen in the stratosphere called the ozone layer. This layer filters out harmful ultraviolet radiations from the sunlight and thus protects various life forms on the earth.

Ozone is a form of oxygen. The molecule of oxygen contains two atoms whereas that of ozone contains three (O3). In the stratosphere ozone is continuously being created by the absorption of short wave-length ultraviolet (UV) radiations. Ultraviolet radiations less than 242 nanometres decompose molecular oxygen into atomic oxygen (O) by photolytic decomposition.

$$O_2 + hv \rightarrow O + O$$

The atomic oxygen rapidly reacts with molecular oxygen to form ozone.

$$O + O_2 + M \rightarrow O_3 + M$$

(M is a third body necessary to carry away the energy released in the reaction).

Ozone thus formed distributes itself in the stratosphere and ab-sorbs harmful ultraviolet radiations (200 to 320 nm) and is continuously being converted back to molecular oxygen.

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

Absorption of UV radiations results in heating of the stratosphere.

The net result of the above reactions is an equilibrium concentration of ozone. Ozone concentration in about 24 km of the stratosphere i.e. from 16 km to 40 Km away from earth is about 10 ppm (as com-pared to 0.05 ppm concentration of harmful tropospheric ozone). This equilibrium is disturbed by reactive atoms of chlorine, bromine etc. which destroy ozone molecules and result is thinning of ozone layer generally called ozone hole

The amount of atmospheric ozone is measured by 'Dobson Spectrometer' and is expressed in Dobson units (DU). One DU is equivalent to a 0.01 mm thickness of pure ozone at the density it would possess if it were brought to ground level (1atm) pressure. Normally over temperate latitude its concetration is about 350 DU, over tropics it is 250 DU whereas at subpolar regions (except when ozone thinning occurs) it is on an average 450 DU. It is because of the stratospheric winds which transport ozone from tropical towards polar regions

Effects of Ozone Depletion

- Ozone depletion in the stratosphere will result in more UV radiation reaching the earth especially UV-B (290-320 nm). The UV-B radiations affect DNA and the photosynthetic chemicals. Any change in DNA can result in mutation and cancer. Cases of skin cancer (basal and squamous cell carcinoma) which do not cause death but cause disfigurement will increase.
- Easy absorption of UV rays by the lens and cornea of eye will result in increase in incidents of cataract.
- Melanin producing cells of the epidermis (important for hu-man immune system) will be destroyed by UV-rays resulting in immuno-suppression. Fair people (can't produce enough melanin) will be at a greater risk of UV exposure.

- Phytoplanktons are sensitive to UV exposure. Ozone deple-tion will result in decrease in their population thereby affect-ing the population of zooplankton, fish, marine animals, in fact the whole aquatic food chain.
- Yield of vital crops like corn, rice, soybean, cotton, bean, pea, sorghum and wheat will decrease.
- Degradation of paints, plastics and other polymer material will result in economic loss due to effects of UV radiation resulting from ozone depletion

Unit 4
WASTE MANAGEMENT

SOLID WASTE MANAGEMENT

Solid waste (waste other than liquid or gaseous) can be classified as municipal, industrial, agricultural, medical, mining waste and sewage sludge.

Sources of Urban and Industrial Wastes

Urban waste consists of medical waste from hospitals; municipal solid wastes from homes, offices, markets (commercial waste) small cottage units, and horticulture waste from parks, gardens, orchards etc.

- Waste from homes (Domestic waste) contains a variety of discarded materials like polyethylene bags, empty metal and aluminium cans, scrap metals, glass bottles, waste paper, diapers, cloth/rags, food waste etc.

- Waste from shops mainly consists of waste paper, packaging material, cans, bottles, polyethylene bags, peanut shells, eggshells, tea leaves etc.

- Biomedical waste includes anatomical wastes, pathological wastes, infectious wastes etc.

- Construction/demolition waste includes debris and rubbles, wood, concrete etc.

- Horticulture waste and waste from slaughter houses include vegetable parts, residues and remains of slaughtered animals, respectively.
- Industrial waste: Industrial waste consists of a large number of materials including factory rubbish, packaging material, organic wastes, acids, alkalis and metals etc. During some industrial processing large quantities of hazardous and toxic materials are also produced. The main sources of industrial wastes are chemical industries, metal and mineral processing industries. Radioactive wastes are generated by nuclear power plants. Thermal power plants produce fly ash in large quantities. Solid wastes from other types of industries include scrap metal, rubber, plastic, paper, glass, wood, oils, paints, asphalt, tars, dyes, scrap leather, ceramics, abrasives, slag, heavy metals, asbestos, batteries.

The urban solid waste materials that can be degraded by micro-organisms are called biodegradable wastes. Examples of this type of waste are vegetable wastes, stale food, tea leaves, egg shells, peanut shells, dry leaves etc. Wastes that cannot be degraded by micro-organisms are called non-biodegradable wastes. For example, polyethylene bags, scrap metal, glass bottles etc.

Effects of Solid Wastes

Municipal solid wastes heap up on the roads due to improper disposal system. People clean their own houses and litter their immediate surroundings which affects the community including themselves. This type of dumping allows biodegradable materials to decompose under uncontrolled and unhygienic conditions. This produces foul smell and breeds various types of insects and infectious organisms besides spoiling the aesthetics of the site.

Industrial solid wastes are sources of toxic metals and hazardous wastes, which may spread on land and can cause changes in physico-chemical and biological characteristics thereby affecting productivity of soils. Toxic substances may leach or percolate to contaminate the ground water.

In refuse mixing the hazardous wastes are mixed with garbage and other combustible waste. This makes segregation and disposal all the more difficult and risky. Various types of wastes like cans, pesticides, cleaning solvents, batteries (zinc, lead or mercury) radioactive materials, plastics are mixed up with paper, scraps and other non-toxic materials which could be recycled. Burning of some of these materials produce dioxins, furans and polychlorinated biphenyls, which have the potential to cause various types of ailments including cancer.

Management of Solid Waste: For waste management we stress on 'three R's'-Reduce, reuse and recycle before destruction and safe storage of wastes.

(i) Reduction in use of raw materials: Reduction in the use of raw materials will correspondingly decrease the production of waste. Reduced demand for any metallic product will decrease the mining of their metal and cause less production of waste.

(ii) Reuse of waste materials: The refillable containers which are discarded after use can be reused. Villagers make casseroles and silos from waste paper and other waste materials. Making rubber rings from the discarded cycle tubes which are used by the newspaper vendors, instead of rubber bands, reduces the waste generation during manufacturing of rubber bands. Because of financial constraints poor people reuse their materials to the maximum.

(iii) Recycling of materials: Recycling is the reprocessing of discarded materials into new useful products.

(i) Formation of some old type products e.g. old aluminium cans and glass bottles are melted and recast into new cans and bottles.

(ii) Formation of new products: Preparation of cellulose insulation from paper, preparation of fuel pellets from kitchen waste. Preparation of automobiles and construction materials from steel cans.

The process of reducing, reusing and recycling saves money, energy, raw materials, land space and also reduces pollution. Recycling of paper will reduce cutting of trees for making fresh paper. Reuse of metals will reduce mining and melting of ores for recovery of metals from ores and prevent pollution

Discarding of Solid Wastes

For discarding wastes the following methods can be adopted:

(i) Sanitary landfill: In a sanitary landfill, garbage is spread out in thin layers, compacted and covered with clay or plastic foam.

In the modern landfills the bottom is covered with an impermeable liner, usually several layers of clay, thick plastic and sand. The liner protects the ground water from being contaminated due to percolation of leachate. Leachate from bottom is pumped and sent for treatment. When landfill is full it is covered with clay, sand, gravel and top soil to prevent seepage of water. Several wells are drilled near the landfill site to monitor if any leakage is

contaminating ground water. Methane produced by anaerobic decomposition is collected and burnt to produce electricity or heat.

(ii) Composting: Due to shortage of space for landfill in bigger cities, the biodegradable yard waste (kept separate from the municipal waste) is allowed to degrade or decompose in an oxygen rich medium. A good quality nutrient rich and environmental friendly manure is formed which improves the soil conditions and fertility.

(iii) Incineration: Incinerators are burning plants capable of burning a large amount of materials at high temperature. The initial cost is very high. During incineration high levels of dioxins, furans, lead and cadmium may be emitted with the fly ash of incinerator. Dioxin level may reach many times more than in the ambient environment. For incineration of materials, it is better to remove batteries containing heavy metals and plastic containing chlorine before burning the material. Prior removal of plastics will reduce emissions of dioxins and polychlorinated biphenyls (PCBs).

e-WASTE MANAGEMENT

"Electronic waste" or "E-Waste" may be defined as discarded computers, office electronic equipment, entertainment device electronics, mobile phones, television sets, and refrigerators. This includes used electronics which are destined for reuse, resale, salvage, recycling, or disposal.

Unit 5: SOCIAL ISSUES AND THE ENVIRONMENT

SUSTAINABLE DEVELOPMENT

Sustainable development is defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs."

Sustainable development implies using the natural resources in such a manner
which doesn't eliminate or diminish their usefulness for future generations eg: coal, crude oil; forests_. Hence, the concept of Sustainable Development could be termed development without destruction.
Measures for Sustainable Development: Following are the measures for the sustainable development:

1. Population Control: Population growth should be limited to the desirable level. Slow human population growth, reduce the stress on global life.
2. Biodiversity (variety of life on earth and how the living things interact with each other) must be conserved.
3. Recycling of wastes: Recycle at least 60% of the materials which are discarded now as trash.
4. Reduced Consumption: Lifestyle should be shifted to lesser consumption of resources.
5. Efficient usage of Resources: Resources should be renewed or reused. For eg: solar energy should be encouraged.
6. Water Resource Management: Some of the consequences of poor water resource management such as
   (A) River flooding; (B) Silting of reservoirs, ponds, lakes;
   (C) over exploitation of groundwater; (D) Water logging by over irrigation
   (E) Improper drainage (F) Pollution of water bodies

are to be taken up for implementation. So, Sustainable development insists optimum management of water resources locally and globally.

7. Integrated Land use planning: Using lands for agriculture, forestry, fodder cultivation, industrial growth, traffic etc should be planned.
8. Creating Awareness: Creation of environmental awareness and spreading environmental education among the people is must for fruitful results..

Threats To Sustainability: Though the measures are adopted for implementation of Sustainable Development , some of the threats such as Energy depletion; climate system collapse; ecological collapse; Economic slump etc are reduce the sustainability of life.

- Energy depletion: The availability of crude oil resources are less and usage is more and more. Since the increased number of human beings mainly dependent on energy source especially fossil fuels, the future generation will have to work hard to restructure the way they live.
- Climate system collapse: Huge quantities of Green House Gases have been releasing into the atmosphere over the last 100 years. And more is being released every day, future generation may be unstable with the climate systems of floods, storms, droughts, extreme temperatures etc

- Ecological collapse: Numerous industries are coming up by consuming the natural resources and releasing the toxic substances into the atmosphere. These substances cause soil pollution, air pollution; water pollution and in turn causing the imbalance of ecosystem.
- Economic slump: Although the world has never had an economic recession all over, there may be a global economic depression may takes place because of the destruction of ecosystem.

ENVIRONMENTAL EDUCATION

- Education plays a very important role in dealing with the global issue.
- Environmental Education is an integral process, which deals with man's interrelationship with his (natural and man made) surroundings viz., relation of population, pollution, resource allocation, resource depletion, conservation, technology; urban and rural planning.
- Environmental Education is intended to promote the awareness and understanding of the environment among the citizens. Hence, Environmental Education is meant to bring about the required changes in knowledge, understanding attitudes and skills pertaining to the environment, conservation and ecological balance.
- So, Environmental Education must be considered as a solution for all environmental problems and the goal of Environmental Education should be to improve and enhance the quality of life.

The objectives of Environmental Education are:

- Awareness--- to help individuals acquire an awareness of environment and its allied problems.
- Knowledge--- to acquire basic understanding of the environment
- Skills--- to acquire the skills for solving environmental problems. Participation-to develop responsibility regarding environmental problems to ensure appropriate action to solve those problems.

Importance of Environmental Education:

The importance of environmental protection has long been recognized in our country. Article 51 (g) of the constitution states " It shall be the duty of every citizen to protect and improve the Natural environment including forests, lakes, rivers, wild life" etc..

Education about environment provides learners with the know how on environment. Education for environment will be concerned about conservation, preservation and upgradation.

Conservation of Natural Resources: As the human population increases, greater demands are placed upon the available natural resources. Large areas of the earth are being converted for the exclusive use of man. Thus, many valuable natural resources, which were available yesterday are not seen today.

At present, world environment is suffering critical stress not only by utilization of natural resources but also with the environmental damage inflicted by deforestation, species loss and climate change. So, a new environmental ethic with responsibility is required to recognize the earth's limited capacity of natural resources. This ethic must motivate the people to effect the needed changes.

The global population had already crossed 6 billions and may reach 8 billions by 2019 while the per capita availability of forests, pasture lands, crop lands etc will be decreased. Resources consumption in developed countries causes significant pollution problems, environmental degradation and resource depletion. For eg: an average US citizen consumes 50 times as much as the average citizen of India.

Hence, there must be a holistic way of thinking regarding the management of land resources, water resources, forest resources etc..

Over-exploitation of resources: The over-use or over-harvesting of plants, animals or natural resources threatens the Earth's biodiversity is called as overexploitation.

Over-exploitation causes diminishing of resources which include medicinal plants, forest wood, grazing pastures, fish stocks, forests; water aquifers and species extinctions. If over-exploitation is sustained, it can lead to the destruction of the environment.

Over-hunting has been a significant cause of the extinction of hundreds of species including whales large mammals etc. Commercial hunting, both legal and illegal is the principal threat.

Deforestation, Desertification, Extinction of species; Soil erosion; Fossil fuel depletion; Ozone depletion; increase of Green House Gases etc may arise from over-exploitation of natural resources.