MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

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ENVIRONMENTAL STUDIES

B.Tech – I Year – II Semester

DEPARTMENT OF HUMANITIES AND SCIENCES

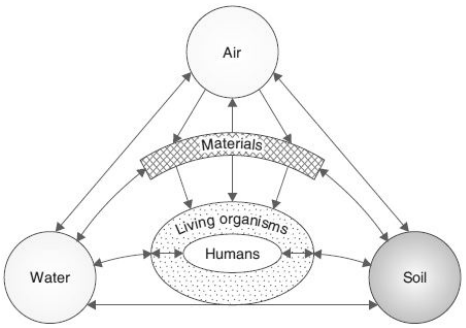
Unit 1: Ecosystems

Introduction

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

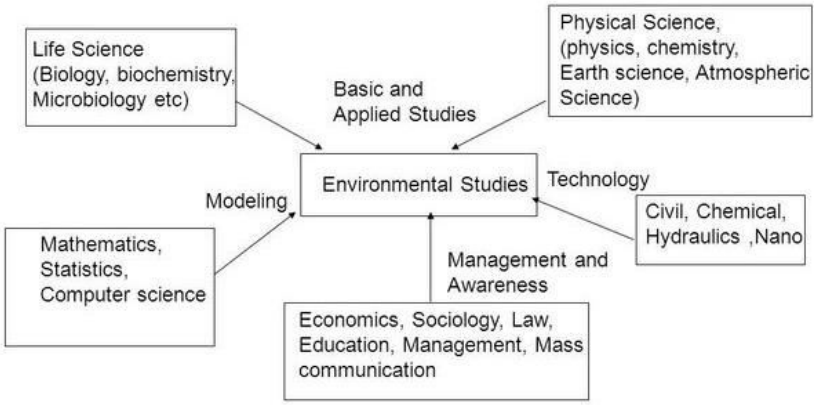
All the biological and non-biological things surrounding an organism are thus included in environment.

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.

Trophic 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)

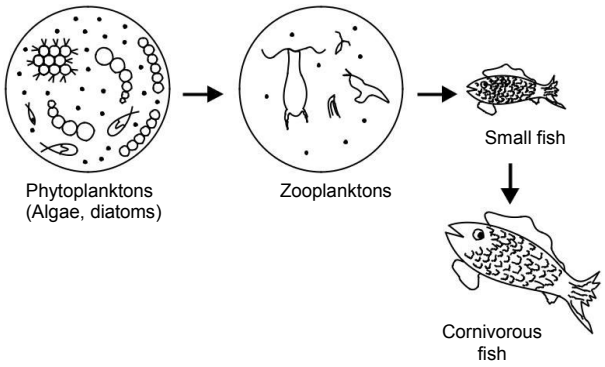
Phytoplanktons → water fleas → small fish → Tuna (Pond ecosystem)

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 <u>two major types of food chains.</u>

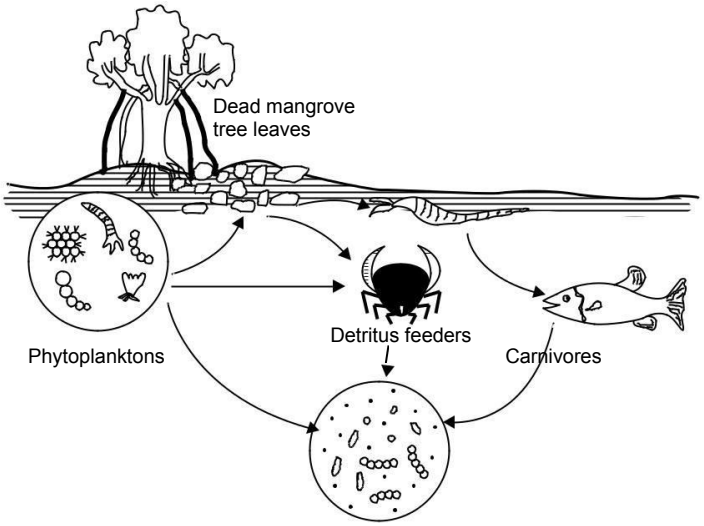
<u>1. Grazing food chain</u>: It **starts with green plants** (primary producers) and culminates in carnivores. All the examples cited above show this type of food chain. Another example could be

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)



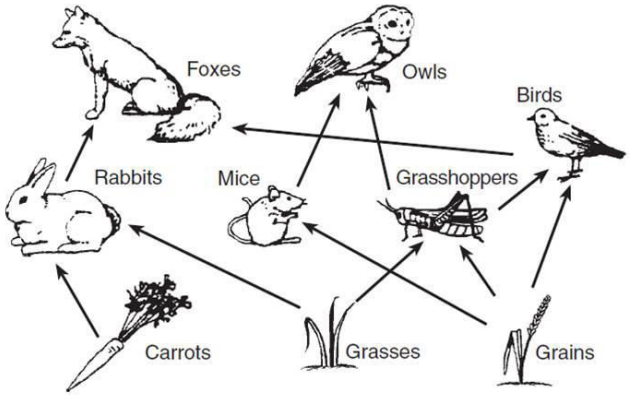
A detritus food chain in an estuary based on dead leaves of mangrove trees

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."



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.

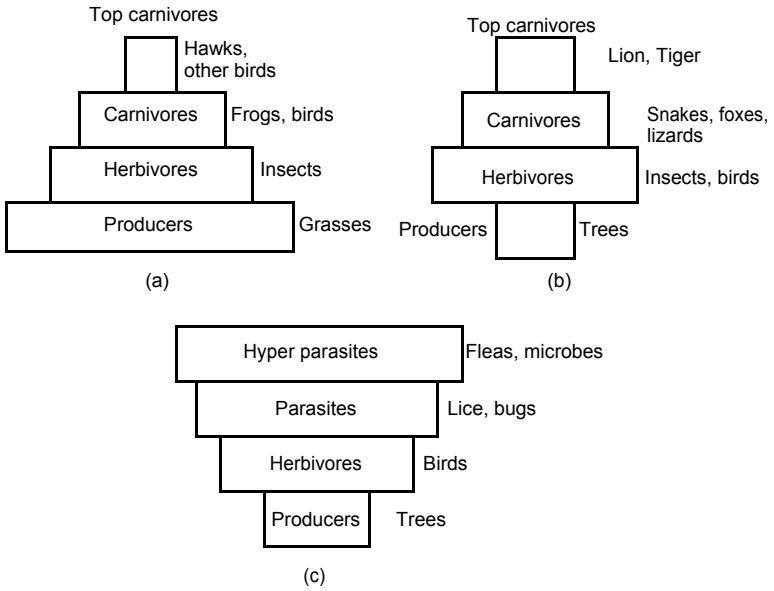
- The food chains also help in maintaining and regulating the population size of different animals and thus, help maintain the ecological balance.
- Food chains show a unique property of biological magnification of some chemicals.

ECOLOGICAL PYRAMIDS

Graphic representation of trophic 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.

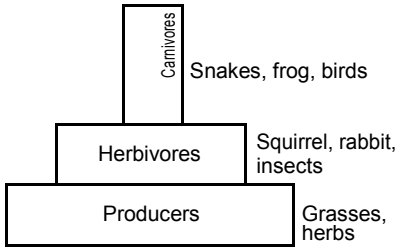
Ecological pyramids are of three types:

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.



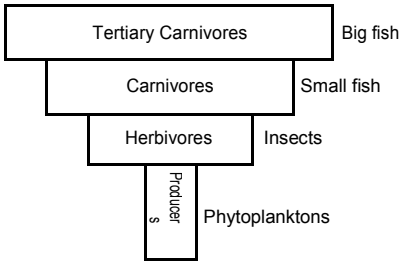
- A grassland ecosystem (Fig. a) and a pond ecosystem show an upright pyramid of numbers. The producers in the grasslands are grasses and that in a pond are phyto planktons (algae etc.), which are small in size and very large in number. So the producers form a broad base. The herbivores in a grassland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

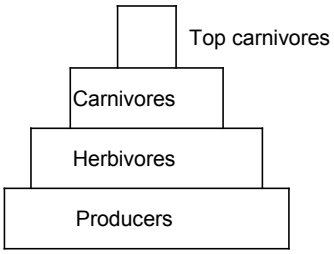
above Fig. (a, b) shows pyramids of biomass in a forest and an aquatic ecosystem. The pyramid of biomass in a forest is upright in contrast to its pyramid of numbers. This is because the producers (trees) accumulate a huge biomass while the consumers' total biomass feeding on them declines at higher 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 (phytoplanktons) is much less as compared to herbivores (zooplanktons, insects), Carnivores (Small fish) and tertiary carnivores (big fish). Thus the pyramid takes an inverted shape with narrow base and broad apex

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.

ENERGY FLOW IN AN ECOSYSTEM

- Flow of energy in an ecosystem takes place through the food chain and it is this energy flow which keeps the ecosystem going.

- The most important feature of this energy flow is that it is unidirectional or one-way flow. Unlike the nutrients (like carbon, nitrogen, phosphorus etc.) which move in a cyclic manner and are reused by the producers after flowing through the food chain, energy is not reused in the food chain.

Also, the flow of energy follows the two laws of Thermodynamics:

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

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

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

(a) Universal energy flow model: Energy flow through an ecosystem was explained by E.P. Odum as the universal energy flow model (Fig.). As the flow of energy takes place, there is a gradual loss of energy at every level, thereby resulting in less energy available at next trophic level as indicated by narrower pipes (energy flow) and smaller boxes (stored energy in biomass). The loss of energy is mainly the energy not utilized (NU). This is the energy lost in locomotion excretion etc. or it is the energy lost in respiration (R) which is for maintenance. The rest of the energy is used for production (P)

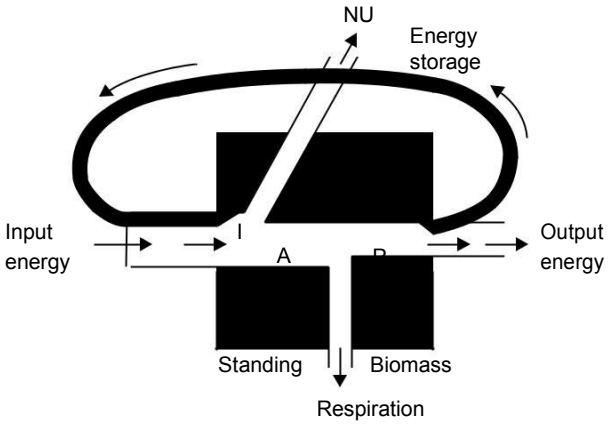


Fig. Universal energy flow model applicable to all living components
(I = Energy input; A : assimilated energy ; P = Production ; NU = Energy not used.

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

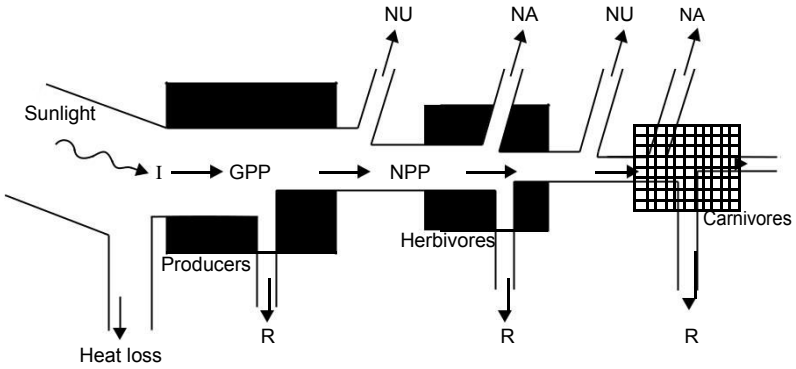
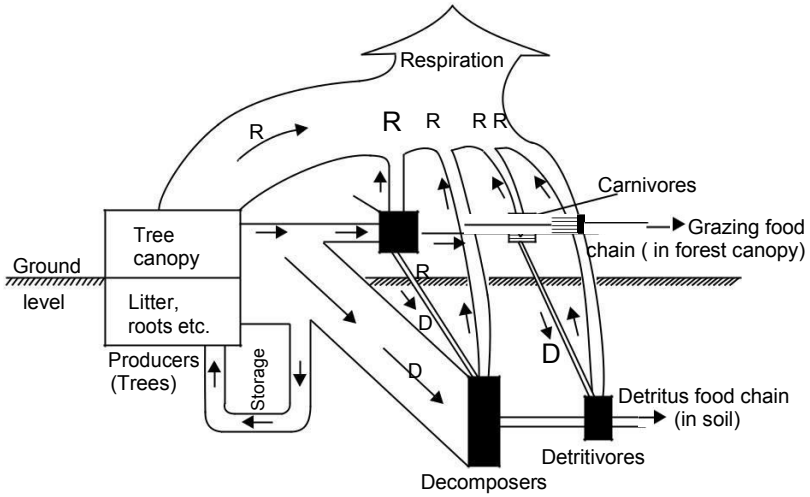


Fig. One-way energy flow model showing unidirectional flow through primary producers, herbivores and carnivores.
At each successive trophic level there is huge loss of energy (I = Solar energy input ; GPP = Gross primary production ; NPP = Net primary production ; NU = Energy not used ; NA = Energy not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

(c) Double channel or Y-shaped energy flow model:

In nature, both grazing food chain and detritus food chain operate in the same ecosystem.

The two channel or Y-shaped model of energy flow shows the passage of energy through these two chains, which are separated in time and space as shown in below figure



NUTRIENT CYCLING or BIOGEOCHEMICAL CYCLE

- Besides energy flow, the other important functional attribute of an ecosystem is nutrient cycling.
- Nutrients like carbon, nitrogen, sulphur, oxygen, hydrogen, phosphorus etc. move in circular paths through biotic and abiotic components and are therefore known as biogeochemical cycles.
- Water also moves in a cycle, known as hydrological cycle.
- The nutrients too move through the food chain and ultimately reach the detritus compartment (containing dead organic matter) where various micro-organisms carry out decomposition. Various organically bound nutrients of dead plants and animals are converted into inorganic substances by microbial decomposition that are readily used up by plants (primary producers) and the cycle starts afresh.

Nitrogen cycle

- Cycling of one such important nutrient nitrogen is shown in below Figure.
- Nitrogen is present in the atmosphere as N2 in large amount (78%) and it is fixed either by the physical process of lightening or biologically by some bacteria and/or cyanobacteria (blue green algae).
- The nitrogen is taken up by plants and used in metabolism for biosynthesis of amino acids, proteins, vitamins etc. and passes through the food chain.
- After death of the plants and animals, the organic nitrogen in dead tissues is decomposed by several groups of ammonifying and nitrifying bacteria which convert them into ammonia, nitrites and nitrates, which are again used by plants.
- Some bacteria convert nitrates, into molecular nitrogen or N2 which is released back into the atmosphere and the cycle goes on.

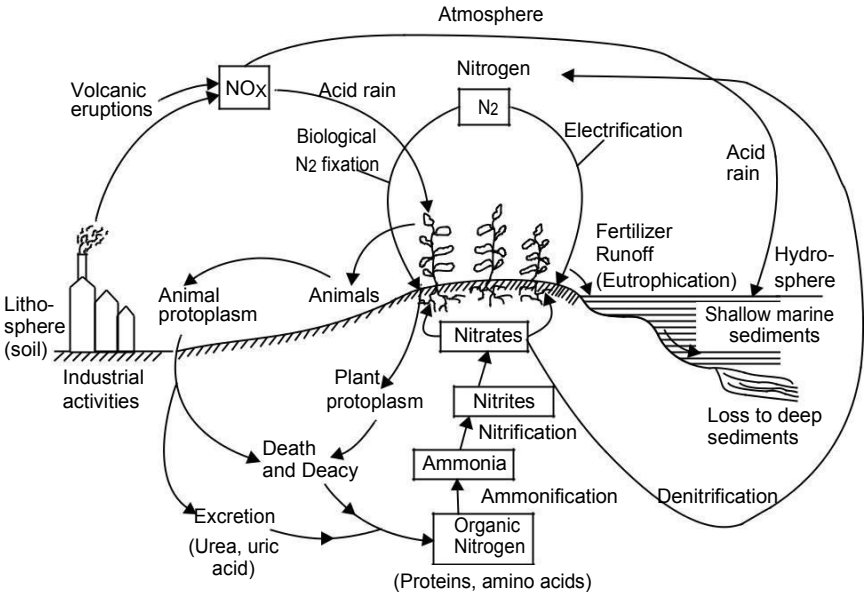
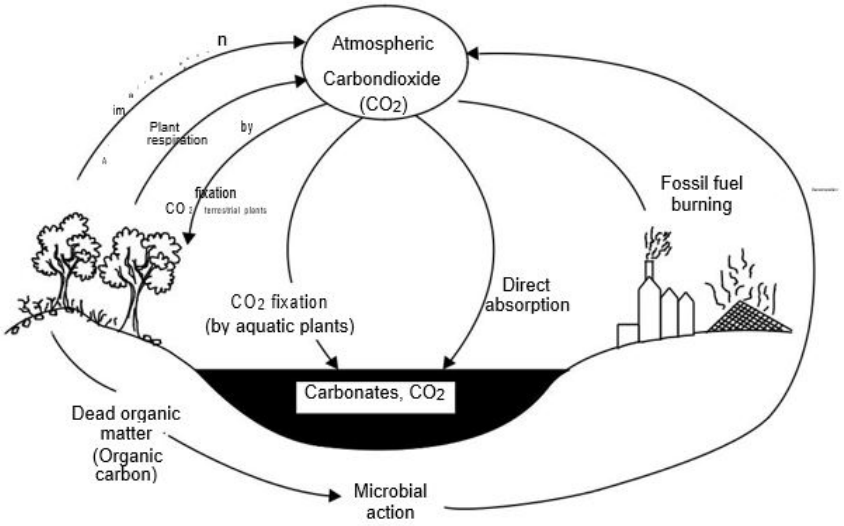


Figure: Nitrogen cycle—a gaseous cycle with major reserve as N2 (78%) in the atmosphere. Circulation of N- between living components and soil/atmosphere is mediated by a group of micro-organisms which convert one form of N into another

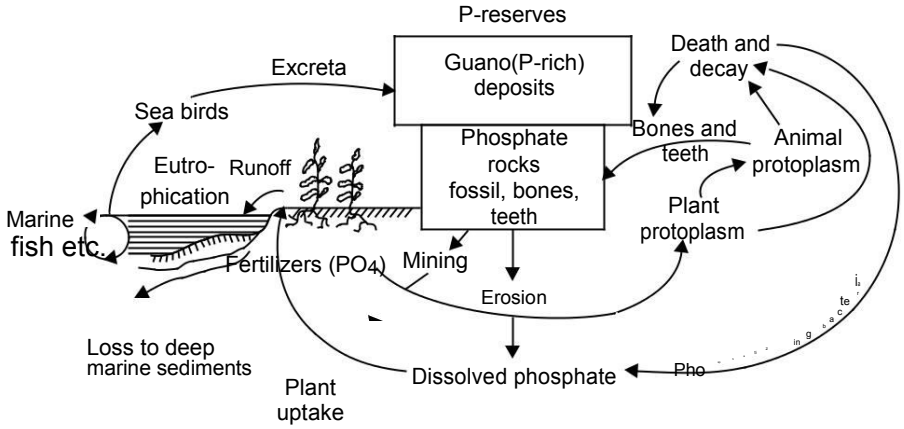
Carbon Cycle

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



Phosphorus cycle

- Phosphorous cycle is another important nutrient cycle-which is shown in Figure.
- The reservoir of phosphorus lies in the rocks, fossils etc. which is excavated by man for using it as a fertilizer.
- Farmers use the phosphate fertilizers indiscriminately and as a result excess phosphates are lost as run-off, which causes the problem of eutrophication or over nourishment of lakes leading to algal blooms as already discussed in unit 2.
- A good proportion of phosphates moving with surface run-off reaches the oceans and are lost into the deep sediments. Our limited supply of phosphorus lying in the phosphate rocks of this earth are thus over-exploited by man and a large part is taken out of the normal cycle due to loss into oceans.
- So human beings are making the phosphorous cycle acyclic. Sea birds, on the other hand, are playing an important role in phosphorus cycling.
- They eat sea-fishes which are phosphorus rich and the droppings or excreta of the birds return the phosphorus on the land.
- The Guano deposits on the coasts of Peru are very rich sources of phosphorus



Primary Production:

Primary productivity of an ecosystem is defined as the rate at which radiant energy is converted into organic substances by photosynthesis or chemo sysnthesis by the primary producers.

- When organic matter is produced by green plants, some of the energy is used for its metabolic activities like respiration and transpiration and burnt inside the body and converted into carbon dioxide and are accompanied by loss of energy.
- Respiratory loss of energy is must because it is required for the maintainence of organism. Now the producers are having little less energy than what they produced.
- This is known as the net primary production (NPP) and the respiratory loss R added to it gives the Gross Primary Productivity(GPP). NPP = GPP - R
- Primary productivity of an ecosystem depends upon the solar radiations, availability of water, and nutrients and upon the type of the plants and their chlorophyll.
- Productivity of tropical forests and estuaries are the highest.
- Because of abundant rainfall, warm temperatures, congenial for growth, abundant sunlight and a rich biodiversity of species.
- Estuaries get natural energy subsidies in the form of wave currents that brings along with them nutrients required for production.
- Deserts have poor rainfall and tundra having low temperatures have less primary productivity.

Secondary Production:

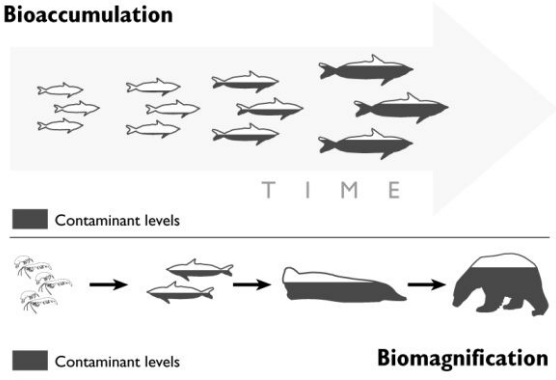
- The food synthesized by green plants through photosynthesis is the primary production which is eaten by herbivores.
- The plants energy is used up for producing organic matter of the herbivores which in turn is used up by the carnivores.
- The amount of organic matter stored by the herbivores or carnivores is known as Secondary Productivity.
- The energy stored at consumer level for use by the next trophic level is defined as Secondary Production

Bioaccumulation:

Bioaccumulation is the accumulation of substances, such as pesticides, or other chemicals in an organism. Bioaccumulation occurs when an organism absorbs a substance at a rate faster than that at which the substance is lost by catabolism and excretion.

or

The toxic substances like pesticides, methyl mercury etc. move into the bodies of organisms from the medium in which these organisms live. Substances like DDT are not water soluble and have affinity for body lipids. These substances tend to accumulate in the organism's body. This process is called bioaccumulation.



Biomagnification:

Biomagnification, also known as bioamplification or biological magnification, is the increasing concentration of a substance, such as a toxic chemical, in the tissues of organisms at successively higher levels in a food chain.

or

The concentration of the toxic substances (pesticides, methyl mercury) builds up at successive levels of food chain. This process is called biomagnification.

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

Non-renewable resources which cannot be regenerated 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 behaviour 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.

Hydrological Cycle

The water we use keeps on cycling endlessly through the environment, which we call as hydrological cycle. We have enormous resources of water on the earth amounting to about 1404 million km

The water from various moist surfaces evaporates and falls again on the earth in the form of rain or snow and passes through living organisms and ultimately returns to the. Oceans. Every year about 1.4 inch thick layer of water evaporates from the oceans, more than 90% of which returns to the oceans through the hydrological cycle. Solar energy drives the water cycle by evaporating it from various water bodies, which subsequently return through rainfall or snow. Plants too play a very important role by absorbing the groundwater from the soil and releasing it into the atmosphere by the process of transpiration.

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

WATER USE AND OVER EXPLOITATION

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

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

Water use by humans is of two types: **water withdrawal** taking water from groundwater or surface water resource and **water consumption** the water which is taken up but not returned for reuse. Globally, only about 60 percent of the water withdrawn is consumed the rest being lost through evaporation.

With increasing human population and rapid development, the world water withdrawal demands have increased many folds and a large proportion of the water withdrawn is polluted due to anthropogenic activities. On a global average, 70 percent of the water withdrawn is used for agriculture. In India, we use 93% of water in agricultural sector while in a country like Kuwait, which is water-poor, only 4% is used for watering the crops. About 25% of water on global average is used in industry which again varies from a high of 70% in European countries to as low as 5% in less developed countries. Per capita use of water shows wide variations. *In USA, all average family of* 4 *consumes more than 1000* m^3 *of water per year, which is many times more than that in most developing countries.*

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

caps and just 0.003% is readily available to us in the form of groundwater and surface water. Overuse of groundwater for drinking, irrigation and domestic purposes has resulted in rapid depletion of groundwater in various regions leading to lowering of water table and drying of wells. Pollution of many of the groundwater aquifers has made many of these wells unfit for consumption.

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

As per the United Nations estimates (2002), at least 10 1 billion people do not even have access to safe drinking water and 2.4 billion do not have adequate sanitation facilities. Increasing population and expanding development would further increase the demands for water. It is estimated that by 2024, two-thirds of the world population would be suffering from acute water shortage.

GROUND WATER

About 9.86% of the total fresh water resources is in the form of groundwater arid it is about 35-50 times that of surface water supplies. Till some time back groundwater was considered to be very pure. However, of late, even groundwater aquifers have been found to be contaminated by leachates from sanitary landfills etc.

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

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

Confined aquifers which are sandwiched between two impermeable layers of rock or sediments and are recharged only in areas

where the aquifer intersects the land surface. Sometimes recharged area is hundreds of kilometers away from the location of well. Fig. 2.1 shows the groundwater system. Groundwater is not it moves, though at a very slow rate of about a meter or so in a year.

Effects of Groundwater Usage

(i) **Subsidence:** When groundwater withdrawal is more than its recharge rate, the sediments in the aquifer get compacted, a phenomenon known as *ground subsidence.* Huge economic losses may occur due to this phenomenon because it results in the sinking of Overlying land surface.

The common problems associated with it include structural damage in buildings, fracture in pipes, reversing the flow of sewers and canals and tidal flooding.

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

*(iii)***Water logging:** When excessive irrigation is done with brackish water it raises the water table gradually leading to water-logging and salinity problems.

SURFACE WATER

The water coming through precipitation (rainfall, snow) when does not percolate down into the ground or does not return to the atmosphere as evaporation or transpiration loss, assumes

the form of streams, lakes, ponds, wetlands or artificial reservoirs known as surface water. The surface water is largely used for irrigation, industrial use, public water supply, navigation etc. A country's economy is largely dependent upon its rivers.

Water rich vs. Water poor countries

The top ten water rich countries are Iceland, Surinam, Guyana, Papua New Guinea, Gabon, Solomon Islands, Canada, Norway, Panama, and Brazil lying in the far north and have low evaporation losses. The water poor countries include Kuwait, Egypt, United Arab Emirates, Malta, Jordan, Saudi Arabia, Singapore, Maldovia, Israel and Oman, lying in the desert belt at about 15° to 25° Latitude and some of them like Malta and Singapore are densely populated areas resulting in low per capita water.

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 tribals living in the area pin big hopes on these projects as they aim at providing employment and raising the standard and quality of life. The dams have tremendous potential for economic upliftment and growth. They can help in checking floods and famines, generate electricity and reduce water and power shortage, provide irrigation water to lower areas, provide drinking water in remote areas and promote navigation, fishery etc.

ENVIRONMENTAL PROBLEMS 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 fur-ther 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.

GROWING ENERGY NEEDS

Development in different sectors relies largely upon energy. Agriculture, industry, mining, transportation, lighting, cooling and heating in buildings all need energy. With the demands of growing population the world is facing further energy deficit. The fossil fuels like coal, oil and natural gas which at present are supplying 95% of the commercial energy of the world resources and are not going to last for many more years. Our life style is changing very fast and from a simple way of life we are shifting to a luxurious life style. If you just look at the number of electric gadgets in your homes and the number of private cars and scooters in your locality you will realize that in the last few years they have multiplied many folds and all of them consume energy.

Developed countries like U.S.A. and Canada constitute about 5% of the world's population but consume one fourth of global energy resources. An average person there consumes 300 GJ (Giga Joules, equal to 60 barrels of oils) per year. By contrast, an average man in a poor country like Bhutan, Nepal or Ethiopia consumes less than 1 GJ in a year. So a person in a rich country consumes almost as much energy in a single day as one person does in a whole year in a poor country. This clearly shows that our lifestyle and standard of living are closely related to energy needs.

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 sulphide 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

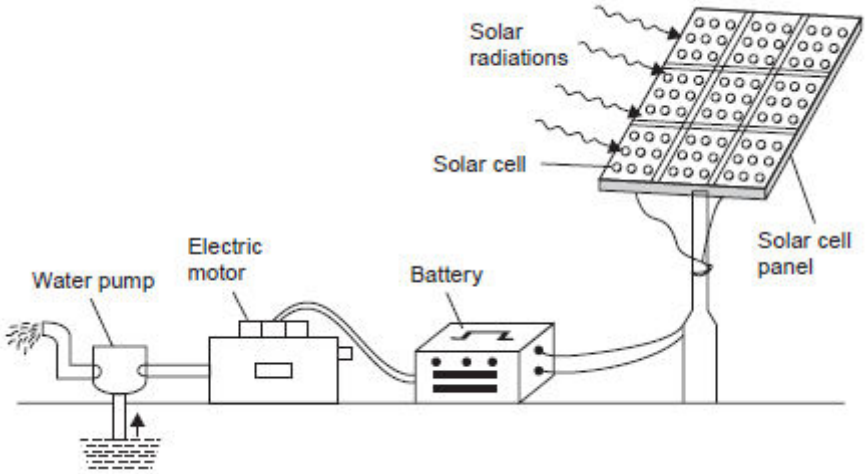


FIG 1 A solar pump run by electricity produced by solar cells.

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.

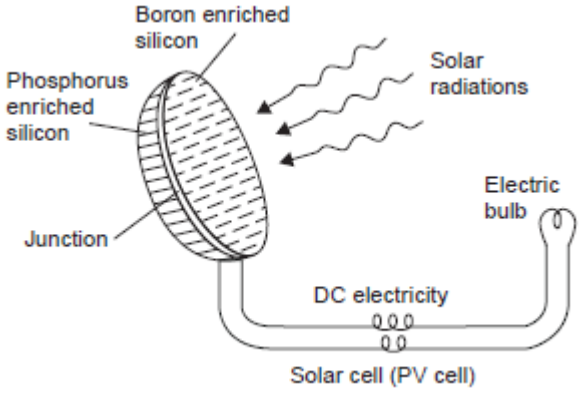


Fig 2 Solar cell.

(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.

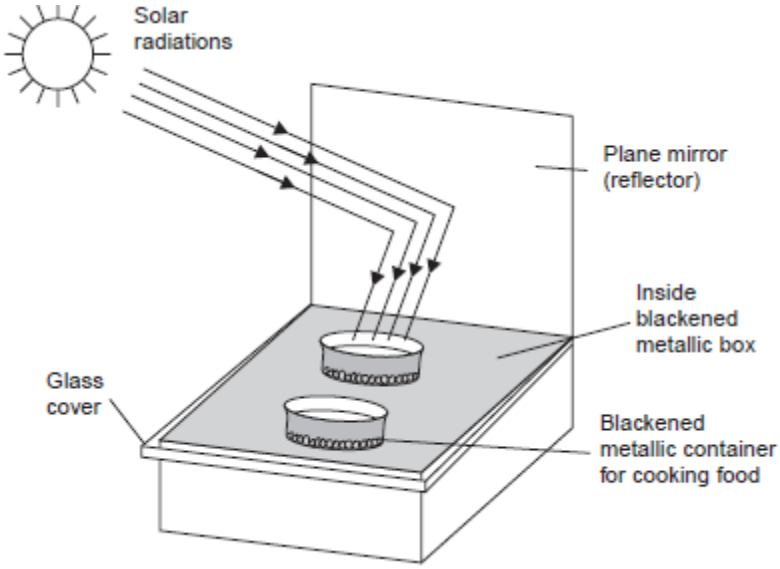


FIG 3 Simple box-type solar cooker.

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

(v) **Solar furnace:** Here thousands of small plane mirrors are arranged in concave reflectors, all of which collect the solar heat and produce as high a temperature as 3000°C.

(vi) **Solar power plant:** Solar energy is harnessed on a large scale by using concave reflectors which cause boiling of water to produce steam. The steam turbine drives a generator to produce electricity. A solar power plant (50 K Watt capacity) has been installed at Gurgaon, Haryana.

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

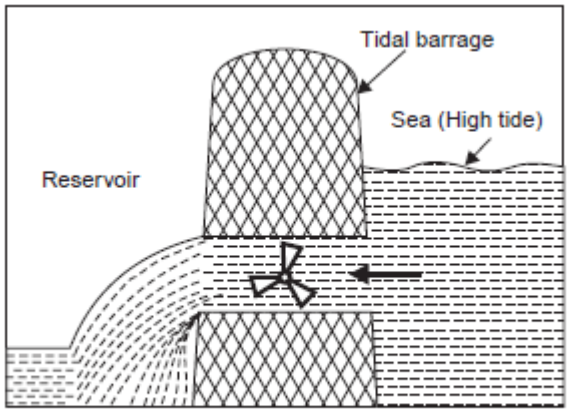
The wind power potential of our country is estimated to be about 20,000 MW, while at present we are generating about 1020 MW. The largest wind farm of our country is near Kanyakumari in Tamil Nadu generating 380 MW electricity.

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

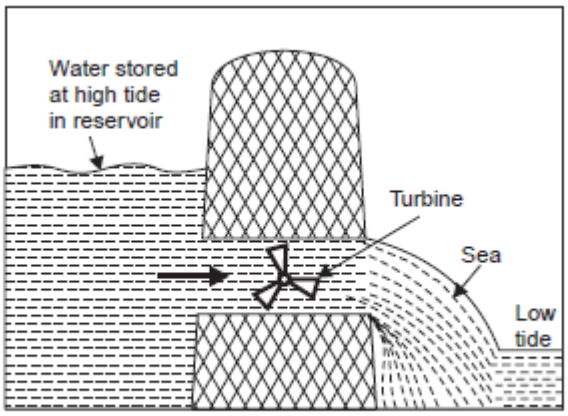
power would supply more than 10% of world's electricity.

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.



(a)



(b)

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 Sunderban deltas are the tidal power sites.

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

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

Biomas energy: Biomass is the organic matter produced by the plants or animals which includes wood, crop residues, cattle dung, manure, sewage, agricultural wastes etc. Biomass energy is of the following types:
(a) **Energy plantation:** Solar energy is trapped by green plants through photosynthesis and converted into biomass energy. Fast growing trees like cottonwood, poplar and *Leucaena,* non-woody herbaceous grasses, crop plants like sugarcane, sweet sorghum and sugar beet, aquatic weeds like water hyacinth and sea-weeds and carbohydrate rich potato, cereal etc. are some of the important energy plantations. They may produce energy either by burning directly or by getting converted into burnable gas or may be converted into fuels by fermentation.
(b) **Petro crops:** Certain latex-containing plants like Euphorbias and oil palms are rich in hydrocarbons and can yield an oil like substance under high temperature and pressure. This oily material may be burnt in diesel engines directly or may be refmed to form gasoline. These plants are popularly known as petro-crops.
(c) **Agricultural and urban waste biomass:** Crop residues, bagasse (sugarcane residues), coconut shells, peanut hulls, cotton stalks etc. are some of the common agricultural wastes which produce energy by burning. Animal dung, fishery and poultry waste and even human refuse are examples of biomass energy. In Brazil 30 % of electricity is obtained from burning

bagasse. In rural India, animal dung cakes are burnt to produce heat. About 80 % of rural heat energy requirements are met by burning agricultural wastes, wood and animal dung cakes.
In rural areas these forms of waste biomass are burned in open furnaces called 'Chulhas' which usually produce smoke and are not so efficient (efficiency is < 8%). Now improved Chulhas with tall chimney have been designed which have high efficiency and are smokeless.
The burning of plant residues or animal wastes cause air pollution and produce a lot of ash as waste residue. The burning of dung destroys essential nutrients like Nand P. It is therefore, more useful to convert the biomass into biogas or bio fuels.

Biogas:

Biogas is a mixture of methane, carbon dioxide, hydrogen and Hydrogen sulphide, the major constituent being methane. Biogas is produced by anaerobic degradation of animal wastes (sometimes plant wastes) in the presence of water. Anaerobic degradation means breakdown of organic matter by bacteria in the absence of oxygen.
Biogas is a non-polluting, clean and low cost fuel which is very useful for rural areas where a lot of animal waste and agricultural waste are available. India has the largest cattle population in the world (240 million) and has tremendous potential for biogas production. From cattle dung alone, we can produce biogas of a magnitude of 22,500 Mm^3 annually. A sixty cubic feet gobar gas plant can serve the needs of one average family.
Biogas has the following main advantages: It is clean, non-polluting and cheap. There is direct supply of gas from the plant and there is no storage problem. The sludge left over is a rich fertilizer containing bacterial biomass with most of the nutrients preserved as such. Airtight digestion/ degradation of the animal wastes is safe as it eliminates health hazards which normally occur in case of direct use of dung due to direct exposure to faecal pathogens and parasites.
Biogas plants used in our country are basically of two types:
1. Floating gas-holder type and 2. Fixed-dome type.

1. Floating gas-holder type biogas plant: This type has a well-shaped digester tank which is placed under the ground and made up of bricks. In the digester tank, over the dung slurry an inverted steel drum floats to hold the bio-gas produced. The gas holder can move which is controlled by a pipe and the gas outlet is regulated by a valve. The digester tank has a partition wall and one side of it receives the dung-water mixture through inlet pipe while the other side discharges the spent slurry through outlet pipe .
Sometimes corrosion of steel gas-holder leads to leakage of biogas. The tank has to be painted time and again for maintenance which increases the cost. Hence another type was designed as discussed below:

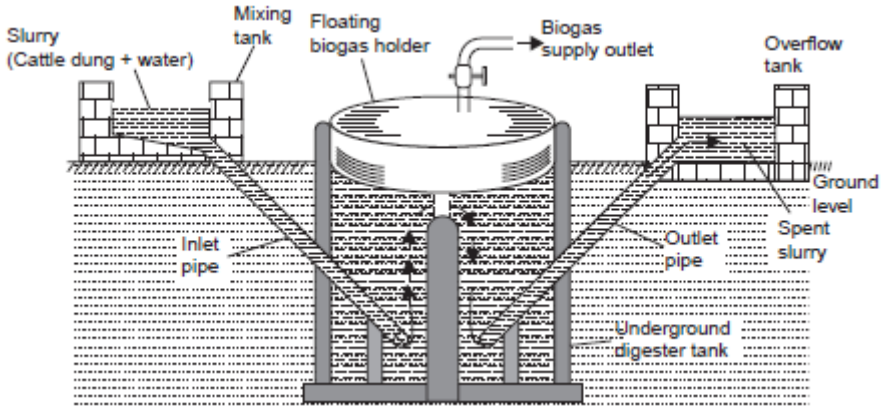


FIG 6 Floating gas holder type biogas plant.

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

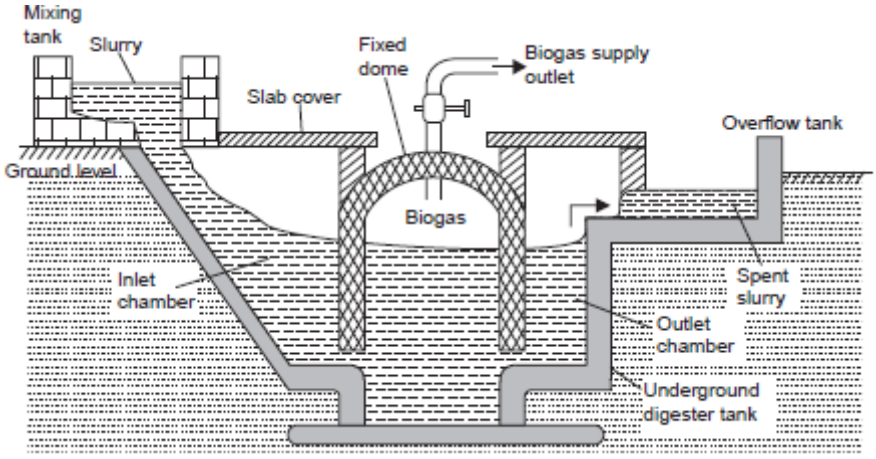


FIG 7 Fixed dome type Biogas plant.

Biofuels: Biomass can be fermented to alcohols like ethanol and methanol which can be used as fuels. **Ethanol** can be easily produced from carbohydrate rich substances like sugarcane, corn and sorghum (Jowar). It burns clean and is non-polluting. However, as compared to petrol its calorific value is less and therefore, produces much less heat than petrol. It is also considered to be an excellent substitute for kerosene and its combustion is as clean as LPG.

Gasohol: is a common fuel used in Brazil and Zimbabwe for running cars and buses, In India too gasohol is being used on trial basis in some parts of the country. Gasohol is a mixture of ethanol and gasoline.

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

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

Hydrogen as fuel: As hydrogen burns in air, it combines with oxygen to form water and a large amount of energy (150 kilojoules per gram) is released, Due to its high, rather the highest calorific value, hydrogen can serve as an excellent fuel. Moreover, it is non-polluting and can be easily produced. Production of hydrogen is possible by thermal dissociation, photolysis or electrolysis of water:

(i) By thermal dissociation of water (at 3000^0K or above) hydrogen H_2 is produced.

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

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

(iv) Photolysis of water involves breakdown of water in the presence of sunlight to release

hydrogen. Green plants and micro-algae also have photolysis of water during photosynthesis. Efforts are underway to trap hydrogen molecule which is produced during photosynthesis. However, hydrogen is highly inflammable and explosive in nature. Hence, safe handling is required for using H2 as a fuel. Also, it is difficult to store and transport. And being very light, it would have to be stored in bulk.

Presently, H_2 is used in the form of liquid hydrogen as a fuel in spaceships H_2 can be used in fuel cell to generate electricity. In fuel cell hydrogen is burnt in air or oxygen in the presence of an electrolyte to produce electricity.

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 odourless, but the LPG in our domestic gas cylinders gives a foul smell. This is, in fact, due to ethyl mercaptan, a foul smelling gas, added to LPG so that any leakage of LPG from the cylinder can be detected instantaneously.
Oil fields in 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. 68 *Chapter 2*
Synthetic Natural Gas (SNG): It is a mixture of carbon monoxide and hydrogen. It is a connecting link between a fossil fuel and substituted natural gas. Low grade coal is initially transformed into synthetic gas by gasification followed by catalytic conversion to methane.

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

(i) **Nuclear fission:** It is the nuclear change in which nucleus of certain isotopes with large mass numbers are split into lighter nuclei on bombardment by neutrons and a large amount of energy is released through a chain reaction,

$$U^{235} + n^{1} \longrightarrow Kr^{92} + Ba^{141} + 3\,n^{1} + \text{Energy}$$

Nuclear Reactors make use of nuclear chain reaction. In order to control the rate of fission, only 1 neutron released is allowed to strike for splitting another nucleus. Uranium-235 nuclei are most commonly used in nuclear reactors.

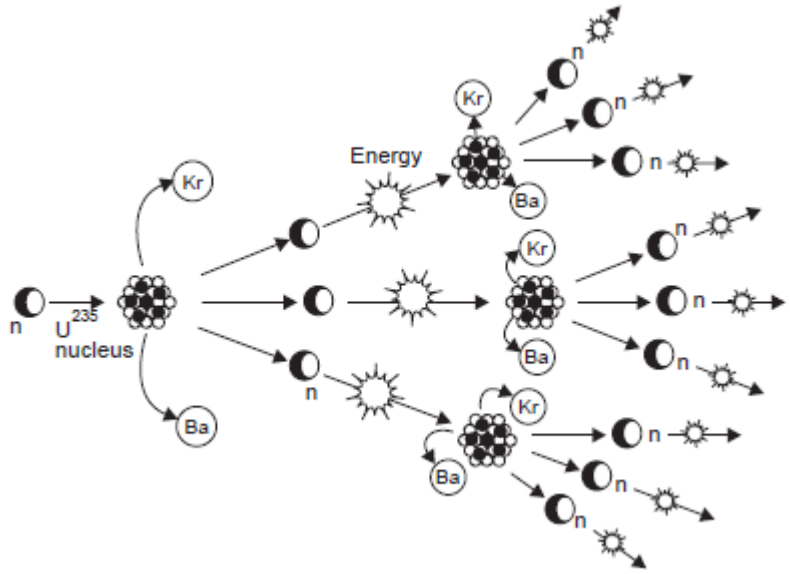


FIG 8 Nuclear fission—a chain reaction initiated by one neutron that bombards a Uranium (U^{235}) nucleus,

(ii) **Nuclear fusion:** Here two isotopes of a light element are forced together at extremely high temperatures (1 billion °C) until they fuse to form a heavier nucleus releasing enormous energy in the process. It is difficult to initiate the process, but it releases more energy than nuclear fission.

$$H^2 + H^2 \longrightarrow He^2 + n^1 + \text{Energy}$$

Two hydrogen-2 (Deuterium) atoms may fuse to form the nucleus of Helium at 1 billion °C and release a huge amount of energy. Nuclear fusion reaction can also take place between one Hydrogen-2 (Deuterium) and one Hydrogen-3 (Tritium) nucleus at 100 million °C forming Helium4 nucleus, one neutron and a huge amount of energy.

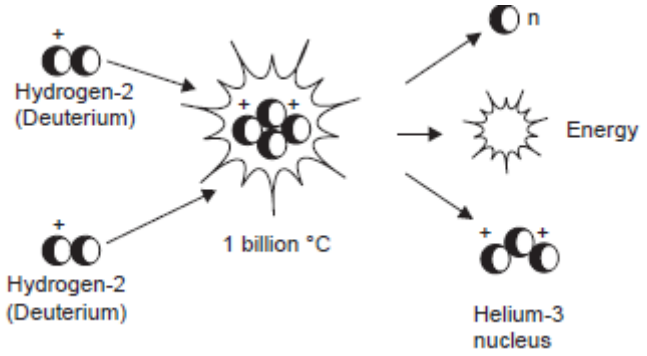


FIG 9 Nuclear fusion reaction between twohydrogen-2 nuclei, which take place at a very high temperature of 1 billion °C; one neutron and one fusion nucleus of helium-3 is formed along with a huge amount of energy.

Nuclear energy has tremendous potential but any leakage from the reactor may cause devastating nuclear pollution. Disposal of the nuclear waste is also a big problem.
Nuclear power in India is still not very well developed. There are four nuclear power stations with an installed capacity of 2005 MW. These are located at Tarapur (Maharashtra), Rana Pratap Sagar near Kota (Rajasthan), Kalpakkam (Tamil Nadu) and Narora (UP.).

Unit 3: Biodiversity and Biotic Resources

DEFINITION

Biodiversity refers to the variety and variability among all groups of living organisms and the ecosystem complexes in which they occur.

In the Convention Of Biological Diversity (1992), biodiversity has been defined as the variability among living organisms from all sources including *inter alia,* terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part.

LEVELS OF BIODIVERSITY

Units of biodiversity may range from the genetic level within a species to the biota in a specific region and may extend up to the great diversity found in different biomes.

Genetic Diversity

It is the basic source of biodiversity. The genes found in organisms can form enormous number of combinations each of which gives rise to some variability. Genes are the basic units of hereditary information transmitted from one generation to other. When the genes within the same species show different versions due to new combinations, it is called genetic variability. For example, all rice varieties belong to the species *oryza sativa,* but there are thousands of wild and cultivated varieties of rice which show variations at the genetic level and differ in their colour, size, shape, aroma and nutrient content of the grain. This is the genetic diversity of rice.

Species Diversity

This is the variability found within the population of a species or between different species of a community. It represents broadly the species richness and their abundance in a community. There are two popular indices of measuring species diversity known as *Shannon-Wiener index* and *simpson index.*

What is the number of species on this biosphere? The estimates of actual number vary widely due to incomplete and indirect data. The current estimates given by Wilson in 1992 put the total number of living species in a range of 10 million to 50 million. Till now only about 1.5 million living and 300000 fossil species have been actually described and given scientific names. It is quite likely that a large fraction of these species may become extinct even before they are discovered and enlisted.

Ecosystem Diversity

This is the diversity of ecological complexity showing variations in ecological niches, tropic structure, food-webs, nutrient cycling etc. The ecosystems also show variations, with respect to physical parameters like moisture, temperature, altitude, precipitation etc. Thus, there occurs tremendous diversity within the ecosystems, along these gradients. we may consider diversity in forest ecosystem, which is supposed to have mainly pre-dominance of trees. But, while considering a tropical rainforest, a tropical deciduous forest, a temperate deciduous forest and a boreal forest ,the variations observed are just too many and they are mainly due to variations in the above mentioned physical factors .The ecosystem diversity is of great value that must be kept intact. This diversity has developed over millions of years of evolution. If we destroy this diversity, it would disrupt the ecological balance. We cannot even replace the diversity of one ecosystem by that of another. Coniferous trees of boreal forests cannot take up the function of the trees of tropical deciduous forest lands and vice versa, because ecosystem diversity has evolved with respect to the prevailing environmental conditions with well-regulated ecological balance.

HOT SPOTS OF BIODIVERSITY

Areas which exhibit high species richness as well as high species endemism are termed as hot spots of biodiversity. The term was introduced by Myers (1988). There are 25 such hot spots of biodiversity on a global level out of which two are present in India, namely the Eastern Hima-layas and Western Ghats.

These hotspots covering less than 2% of the world's land area are found to have about 50% of the terrestrial biodiversity. According to Myers et al. (2000) an area is designated as a hotspot when it contains at least 0.5% of the plant species as endemics.

About 40% of terrestrial plants and 25% of vertebrate species are endemic and found in these hotspots. After the tropical rain forests, the second highest number of endemic plant species are found in the Mediterranean (Mittermeier). Broadly, these hot spots are in Western Amazon, Madagascar, North and East Borneo, North Eastern Aus-tralia, West Africa and Brazilian Atlantic forests. These are the areas of high diversity, endemism and are also threatened by human activi-ties. More than 1 billion people (about 1/6th of the world's popula-tion) most of whom are desperately poor people, live in these areas. Any measures of protecting these hotspots need to be planned keeping in view the human settlements and tribal issues.

Earlier 12 hot spots were identified on a global level. Later Myers et al (2000) recognized 25 hot spots.. Two of these hotspots lie in India extending into neighbouring countries namely, Indo-Burma region (covering Eastern Himalayas) and Western Ghats - Sri Lanka region. The Indian hot spots are not only rich in floral wealth and endemic species of plants but also reptiles, amphibians, swallow tailed butterflies and some mammals.

(a) Eastern Himalayas: They display an ultra-varied topography that fosters species diversity and endemism. There are numerous deep and semi-isolated valleys in Sikkim which are extremely rich in endemic plant species. In an area of 7298 Km^2 of Sikkim about 4250 plant species are found of which 60% are endemic.

The forest cover of Eastern Himalayas has dwindled to about 1/3rd of its original cover. Certain species like Sapria himalayana, a parasitic angiosperm was sighted only twice in this region in the last 70 years.

Recent studies have shown that North East India along with its contiguous regions of Burma and Chinese provinces of Yunnan and Schezwan is an active center of organic evolution and is considered to be the cradle of flowering plants. Out of the world's recorded flora 30% are endemic to India of which 35,000 are in the Himalayas.

(b) Western Ghats: It extends along a 17,000 Km^2 strip of forests in Maharashtra, Karnataka, Tamil Nadu and Kerala and has 40% of the total endemic plant species. 62% amphibians and 50% lizards are endemic to Western Ghats.

Forest tracts upto 500 m elevation covering 20% of the forest expanse are evergreen while those in 500-1500 m range are semi-evergreen. The major centers of diversity are Agastyamalai Hills and Silent Valley—the New Amambalam Reserve Basin. It is reported that only 6.8% of the original forests are existing today while the rest has been deforested or degraded, which raises a serious cause of alarm, because it means we have already lost a huge proportion of the biodiversity.

Although the hotspots are characterized by endemism, interestingly, a few species are common to both the hotspots in India. Some common plants include Ternstroemia japonica, Rhododendron and Hypericum, while the common fauna includes laughing thrush, Fairy blue bird, lizard hawk etc. indicating their common origin long back in the geological times.

VALUE OF BIODIVERSITY

The value of biodiversity in terms of its commercial utility, ecological services, social and aesthetic value is enormous. We get benefits from other organisms in innumerable ways. Sometimes we realize and appreciate the value of the organism only after it is lost from this earth. Very small, insignificant, useless looking organism may play a crucial role in the ecological balance of the ecosystem or may be a potential source of some invaluable drug for dreaded diseases like cancer or AIDS. The multiple uses of biodiversity or biodiversity value has been classified by McNeely et al in 1990 as follows:

(i) Consumptive use value: These are direct use values where the biodiversity product can be harvested and consumed directly e.g. fuel, food, drugs, fibre etc.

Food: A large number of wild plants are consumed by human beings as food. About 80,000 edible plant species have been reported from wild. About 90% of present day food crops have been domesti-cated from wild tropical plants. Even now our agricultural scientists make use of the existing wild species of plants that are closely related to our crop plants for developing new hardy strains. Wild relatives usu-ally possess better tolerance and hardiness. A large number of wild animals are also our sources of food.

Drugs and medicines: About 75% of the world's population depends upon plants or plant extracts for medicines. The wonder drug Penicillin used as an antibiotic is derived from a fungus called Penicillium. Likewise, we get Tetracyclin from a bacterium. Quinine, the cure for malaria is obtained from the bark of Cinchona tree, while Digitalin is obtained from foxglove (Digitalis) which is an effective cure for heart ailments. Recently vinblastin and vincristine, two anticancer drugs, have been obtained from Periwinkle (Catharanthus) plant, which possesses anticancer alkaloids. A large number of marine animals are supposed to possess anti-cancer properties which are yet to be explored systematically.

Fuel: Our forests have been used since ages for fuel wood. The fossil fuels coal, petroleum and natural gas are also products of fossilized biodiversity. Firewood collected by individuals are not normally marketed, but are directly consumed by tribals and local villagers, hence falls under consumptive value.

(ii) Productive use values: These are the commercially usable val-ues where the product is marketed and sold. It may include lumber or wild gene resources that can be traded for use by scientists for introducing desirable traits in the crops and domesticated animals. These may include the animal products like tusks of elephants, musk from musk deer, silk from silk-worm, wool from sheep, fir of many animals, lac from lac insects etc, all of which are traded in the market. Many industries are dependent upon the productive use values of biodiversity e.g.- the paper and pulp industry, Plywood industry, Railway sleeper industry, Silk industry, textile industry, ivory-works, leather industry, pearl industry etc.

Despite international ban on trade in products from endangered species, smuggling of fur, hide, horns, tusks, live specimen etc. worth millions of dollars are being sold every year. Developing countries in Asia, Africa and Latin America are the richest biodiversity centers and wild life products are smuggled and marketed in large quantities to some rich western countries and also to China and Hong Kong where export of cat skins and snake skins fetches a booming business.

(iii) Social Value: These are the values associated with the social life, customs, religion and psycho-spiritual aspects of the people. Many of the plants are considered holy and sacred in our country like Tulsi (holy basil), Peepal, Mango, Lotus, Bael etc. The leaves, fruits or flowers of these plants are used in worship or the plant itself is worshipped. The tribal people are very closely linked with the wild life in the forests. Their social life, songs, dances and

customs are closely woven around the wildlife. Many animals like Cow, Snake, Bull, Peacock, Owl etc. also have significant place in our psycho-spiritual arena and thus hold special social importance. Thus biodiversity has distinct social value, attached with different societies.

(iv) Ethical value: It is also sometimes known as existence value. It involves ethical issues like "all life must be preserved". It is based on the concept of "Live and Let Live". If we want our human race to survive, then we must protect all biodiversity, because biodiversity is valuable.

The ethical value means that we may or may not use a species, but knowing the very fact that this species exists in nature gives us pleasure. We all feel sorry when we learn that "passenger pegion" or "dodo" is no more on this earth. We are not deriving anything direct from Kangaroo, Zebra or Giraffe, but we all strongly feel that these species should exist in nature. This means, there is an ethical value or existence value attached to each species.

(v) Aesthetic value: Great aesthetic value is attached to biodiversity. No one of us would like to visit vast stretches of barren lands with no signs of visible life. People from far and wide spend a lot of time and money to visit wilderness areas where they can enjoy the aesthetic value of biodiversity and this type of tourism is now known as eco-tourism. The "Willingness to pay" concept on such eco-tourism gives us even a monetary estimate for aesthetic value of biodiversity. Ecotourism is estimated to generate about 12 billion dollars of revenue annually, that roughly gives the aesthetic value of biodiversity.

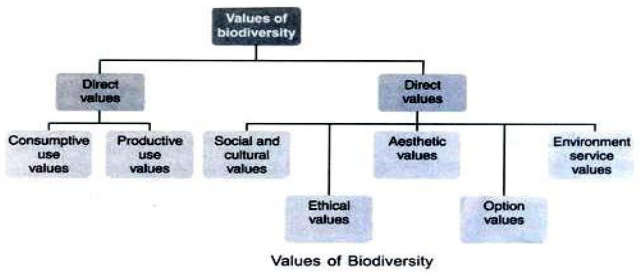
(vi) Option values: These values include the potentials of biodiversity that are presently unknown and need to be explored. There is a possibility that we may have some potential cure for AIDS or can-cer existing within the depths of a marine ecosystem, or a tropical rain-forest.

Thus option value is the value of knowing that there are biological resources existing on this biosphere that may one day prove to be an effective option for something important in the future. Thus, the option value of biodiversity suggests that any species may prove to be a miracle species someday. The biodiversity is like precious gifts of nature presented to us. We should not commit the folly of losing these gifts even before unwrapping them.

The option value also includes the values, in terms of the option to visit areas where a variety of flora and fauna, or specifically some endemic, rare or endangered species exist.

(vii) Ecosystem service value: Recently, a non-consumptive use value related to self maintenance of the ecosystem and various important ecosystem services has been recognized. It refers to the services provided by ecosystems like prevention of soil erosion, prevention of floods, maintenance of soil fertility, cycling of nutrients, fixation of nitrogen, cycling of water, their role as carbon sinks, pollutant absorption and reduction of the threat of global warming etc.

Different categories of biodiversity value clearly indicate that ecosystem, species and genetic diversity all have enormous potential and a decline in biodiversity will lead to huge economic, ecological and socio-cultural losses.



Values of Biodiversity

THREATS TO BIODIVERSITY

Any Disturbance to natural ecosystem tends to reduce its biodiversity. The waste generated in human population and industrialization spoils the environment and leads to more diversity in biological species. Any change in the system leads to major imbalance and threatens the normal ecological cycle. Causes for loss of biodiversity or various threats to Indian biodiversity.

- Habitat Loss
- Poaching of wild life
- Man-Wild life conflicts.

Habitat Loss: The loss of populations of interbreeding organisms is caused by habiatat loss. Habitat loss threatened a wide range of animals and plants.

Factors influencing Habitat loss are:

Deforestation: The loss of habitat is mainly caused by deforestation activities. The forest and grasslands are the natural homes of thousands of species, which disintegrate due to loss of their natural habitat.

Destruction of wetlands: The wetlands, estuaries and mangroves are destroyed due to draining, filling and pollution which cause huge biodiversity loss.

Habitat Fragmentation: Sometimes the habiatat is divided into small and scattered patches. This phenomenon is known as habitat fragmentation. Due to this many wild animals and songbirds are vanishing.

Raw material: For the production of hybrid seeds, the wild plants are used as raw materials. As a result many plant species become extinct.

Production of Drugs: Many pharmaceutical companies collect the wild plants for the production of drugs. Therefore several medicinal plants become extinct..

Illegal Trade: Illegal trade on wild life also reduces the biodiversity and leads to habitat loss.

Developmental activities: Construction of massive dams in the forest areas, discharge industrial effluents which kill the birds and other aquatic organisms.

Poaching: Poaching means killing of animals or commercial hunting. It leads to loss of animal biodiversity.

Subsistence Poaching: killing of animals to provide enough food for their survival is called Subsistence Poaching.

Commercial Poaching: hunting and killing animals to sell their products is called Commercial poaching.

Factors influencing Poaching are human population has led to pressure o forest resources, which ultimately causes degradation of wild life habitats.

International ban on endangered species, smuggling of wild life products like furs, horns, tasks, live specimens, and herbal products makes the hunters to make hunting.

Man- Wildlife Conflicts: Man wildlife conflict arises when wild life starts causing immense damage and danger to the man. Under such conditions it is very difficult for the forest department to compromise the affected villagers and to gain the villagers support for wild life conservation.

Examples of Man- Wild life conflicts:

In sambalpur, Orissa, 195 humans were killed in the last 5 years by elephants. In retaliation the villagers killed 98 elephants and badly injured 30 elephants.
In early 2004, a man- eating tiger has reported to kill 16 Nepalese people and one 4 year old child inside the Royal Chitwan National Park, 240 km south-west of Kathmandu. The park renowned for its wild life conservation effort has became a zone of terror for the locals.
In June 2004, two men were killed by leopards in Powai, Mumbai. A total of 14 persons were killed during 19 attacks in January 2004 by the leopards from the Sanjay Gandhi National Park, Mumbai which created a panic among the local residents.

Causes of Man- Wildlife Conflicts:
Dwindling habitats of tigers, elephants, rhinos and bears due to shrinking forest cover compels them to move outside the forest and attack the field or sometimes the humans. Human's encroachment into the forest areas raises a conflict between man and the wildlife.
Injured animals have a tendency to attack man. Usually the female wildlife attacks the man if she feels that her new borns are in danger.
In search of food that is not available in the forest, the animals come out of the forest.
Often villagers put electric wiring around their crop fields. The elephants get injured, suffer in pain and start violence.
The cash compensation paid by the government for the damage caused by the wild animals is not enough.

Remedial Measures to curb the Conflict:
Tiger conservation Project (TCP) has made provisions for making available vehicles, tranquilizer guns, binoculars and radios sets, to tactfully deal with any imminent danger.
Adequate crop and cattle compensation schemes must be started.
Solar powered fencing must be provided alog with the electric current proof trenches to prevent the animals from entering into the fields.
Cropping pattern should be changed near the forest borders.
Adequate food and water should be made available for the wild animals within the forest zones.
The developmental and constructional work in and around the forests must be stopped.

CONSERVATION OF BIODIVERSITY

The enormous value of Biodiversity due to their genetic, commercial, medical, aesthetic, ecological and optional importance emphasizes the need to conserve of biodiversity.
Advantages of Biodiversity Conservation:
It provides immediate benefits to the society such as recreation and tourism.
Drugs, medicinal plants, herbs and food can be derived from plants and animals.
It also provides the genetic diversity of plants and animals.
Ensures sustainable utilization of life supporting systems on earth.
It leads to conservation of essential ecological diversity and life supporting systems.
Since the biodiversity loss results in ecological and environmental deterioration, it is essential to conserve the biodiversity.
There are two approaches of biodiversity Conservation:

- **In situ Conservation** -within the habitat) Involves protection of fauna and flora within its natural habitat, where the species normally occurs is called the in situ conservation.

The natural habitats or ecosystems maintained under in situ conservation are called "protected areas."E.g. Biosphere reserves, wild life sanctuaries, national parks, reserve forests etc., At present in India, there are 7 major biosphere reserves, 80 national parks, 420 wild life sanctuaries and 120 botanical gardens are present.

Biosphere reserves cover large area, more than5000 sq.km. It is used to protect species for a long time.

A National Park is an area dedicated for the conservation of wild life along with its environment. It is usually a small reserve area covering of about 100 to 500 sq.kms. With in the biosphere, one or two national parks also exist.

Wild life Sanctuaries is an area, which is reserved for the conservation of animals only.

A gene sanctuary is an area where are plants are conserved.

One gene sanctuary for Citrus (Lemon family)

One gene sanctuary for Pitcher Plant(an insect eating plant)

- **Ex situ Conservation:** involves the protection of flora and fauna outside the natural habitats.

  This type of conservation is mainly done for the conservation of crop varieties and the wild relatives of crops, with the main objective of conserving the total genetic diversity of the crop species for future improvement or a forestation programmes..

National Bureau of Plant Genetic Resources (NBPGR): is located in New Delhi. Here the agricultural and horticultural crops and their wild relatives are preserved by cryo-preservation of seeds, pollen grains, etc., by using liquid nitrogen at a temperature as low as -196^0C. For several years with out loosing seed viability.

National Bureau of Animal Genetic Resources: (NBAGR): located at Karnal, Haryana. It preserves the semen of domesticated bovine animals.

National Facility for Plant tissue Culture Repository (NFPTCR): for the development of a facility of conservation of varieties of crop plants /trees by tissue culture. This facility has been created within the NBPGR.

Unit 4: 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.

Indoor Air Pollution

The most important indoor air pollutant is radon gas. Radon gas and its radioactive daughters are responsible for a large number of lung cancer deaths each year. Radon can be emitted from building materials like bricks, concrete, tiles etc. which are derived from soil containing radium. Radon is also present in groundwater and natural gas and is emitted indoors while using them.

Many houses in the under-developed and developing countries including India use fuels like coal, dung-cakes, wood and kerosene in their kitchens. Complete combustion of fuel produces carbon dioxide which may not be toxic. However, incomplete combustion produces the toxic gas carbon monoxide. Coal contains varying amounts of sulphur which on burning produces sulphur dioxide. Fossil fuel burning produces black soot. These pollutants i.e. CO, SO2, soot and many others like formaldehyde, benzo- (a) pyrene (BAP) are toxic and harmful for health. BAP is also found in cigarette smoke and is considered to cause cancer. A house wife using wood as fuel for cooking inhales BAP equivalent to 20 packets of cigarette a day.

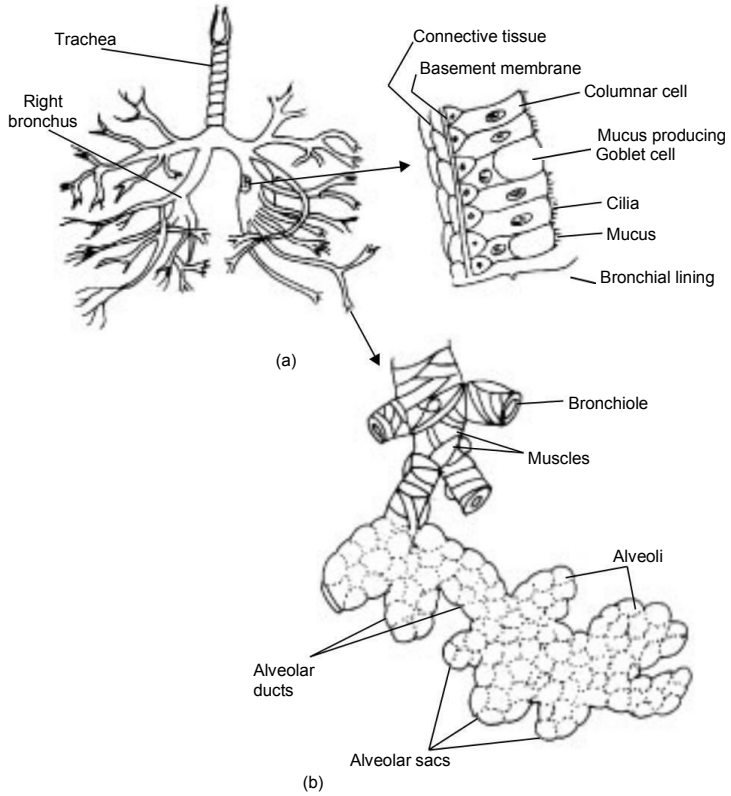
Classification: On the basis of origin of pollutants

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:

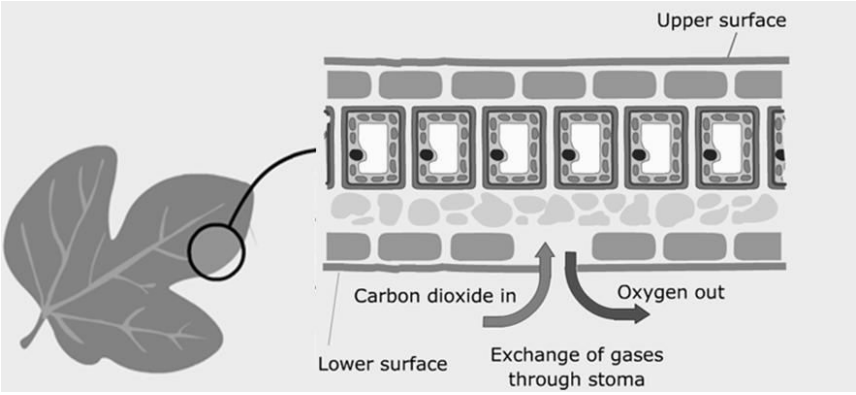
- Human respiratory system has a number of mechanisms for protection from air pollution. Bigger particles (> 10 µm) can be trapped by the hairs and sticky mucus in the lining of the nose. Smaller particles can reach tracheobronchial system and there get trapped in mucus.
- They are sent back to throat by beating of hair like cilia from where they can be removed by spitting orswallowing. Years of exposure to air pollutants (including cigarette smoke) adversely affect these natural defenses 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.

Effects on materials:

- Because of their corrosiveness, particulates can cause damage to exposed surfaces. Presence of SO2 and moisture can accelerate corrosion of metallic surfaces. SO2 can affect fabric, leather, paint, paper, marble and limestone.
- Ozone in the atmosphere can cause cracking of rubber. Oxides of nitrogen can also cause fading of cotton and rayon fibres.

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.

Reduction of Air pollution at sources

Gaseous pollutants

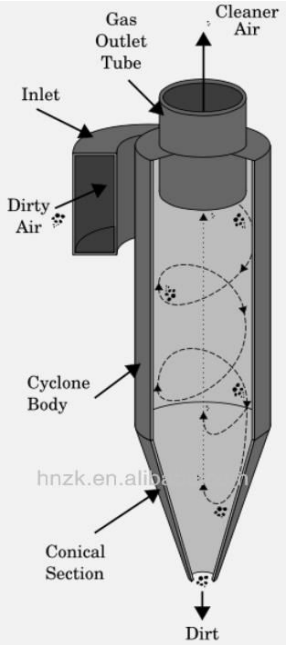
- Physical adsorption on porous solid material like Activated charcoal, silica gel, fuller's earth.
- Effluent gases can be absorbed in liquid absorbents. Ex: SO2 absorbed in ammonia solution.

Particulate pollutants

Many devices are using for particulate pollutants.

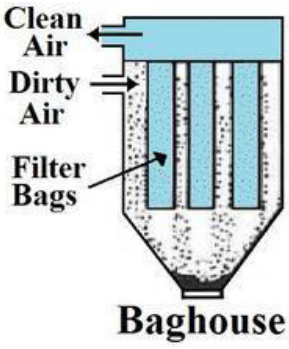
- Cyclone filter
- Bag house filter
- Wet scrubber
- Electrostatic precipitator

Cyclone filter



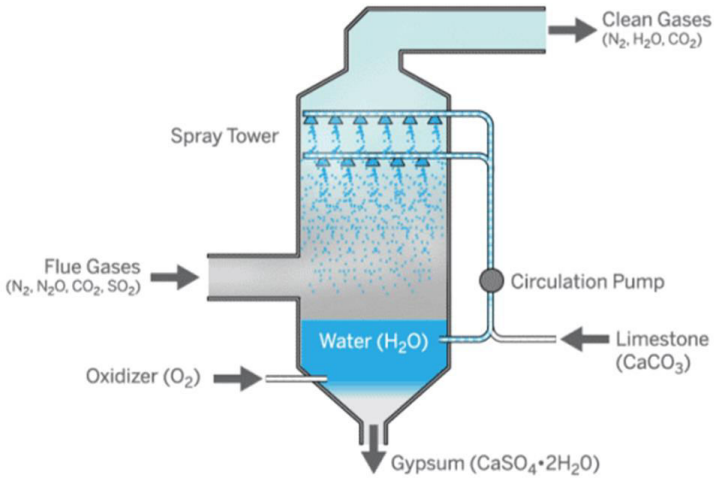
- The gas with particles in it enters tangentially at the top of the cylinder and spins forming a vortex.
- Due to centrifugal force, the particles strike the wall of the cylinder.
- The particles fall in the hopper due to gravity from where they are removed.
- The spinning gas forms an inner vortex and leaves from the top.
- Cyclone filter efficient for larger particles

Bag house filter



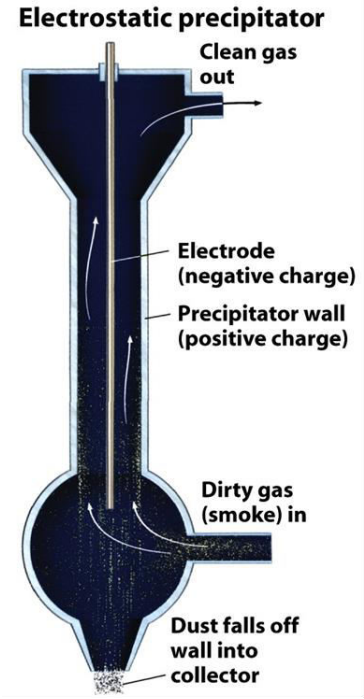
- A bag house filter contains a large number of filter bags made of fabric.
- They are hang upside down in several compartments of bag house filter.
- Dirty gas is passed through the filter bags.
- The dust particles get deposited on the inner surface of bag filter and can removed by shaking mechanism.
- Baghouse filter efficient for smaller particles and can not operate for moist and corrosive gases.

Wet scrubber



- Dirty gas are passed through water in the chamber or water is sprayed on the gas.
- Particles are made wet and are removed from the gas stream which leaves from the top of scrubber.
- Wet scrubber are very efficient for removing the particles and toxic and acidic gases also.

Electrostatic precipitator



- Vertical wire is hung along the axis of cylinder.
- Dust particle while passing form the lower end get negatively charged (ionized) and are collected on positively charged surface (Cylinder surface) while the clean air leaves from the top.
- The deposited dust particles fall down in the dust collector and are removed.

WATER POLLUTION

"Water pollution can be defined as alteration in physical, chemical or biological characteristics of water making it unsuitable for designated use in its natural state".

or

"Water pollution, can, therefore, be defined as any undesirable change in the physical, chemical or biological characteristics of Water, which can cause harmful effects on various form of life."

Sources of water pollution:

- Most of water for such uses comes from rivers, lakes or groundwater sources.
- Water has the property to dissolve many substances in it, therefore, it can easily get polluted.

Pollution of water can be caused by point sources or non-point sources.

- Point sources are specific sites near water which directly discharge effluents into them. Major point sources of water pollution are industries, power plants, underground coal mines, offshore oil wells etc.
- The discharge from non-point sources is not at any particular site, rather, these sources are scattered, which individually or collectively pollute water. Surface run-off from agricultural fields, overflowing small drains, rain water sweeping roads and fields, atmospheric deposition etc. are the non-point sources of water pollution.

Ground water pollution:

- Ground water forms about 6.2% of the total water available on planet earth and is about 30 times more than surface water (streams, lakes and estuaries). Ground water seems to be less prone to pollution as the soil mantle through which water passes helps to retain various contaminants due to its cation exchange capacity.
- However, there are a number of potential sources of ground water pollution. Septic tanks, industry (textile, chemical, tanneries), deep well injection, mining etc. are mainly responsible for ground water pollution, which is irreversible.
- Ground water pollution with arsenic, fluoride and nitrate are posing serious health hazards.

Surface water pollution:

The major sources of surface water pollution are:

- Sewage: Pouring the drains and sewers in fresh water bodies causes water pollution. The problem is severe in cities.
- Industrial effluents: Industrial wastes containing toxic chemicals, acids, alkalis, metallic salts, phenols, cyanides, ammonia, radioactive substances, etc. are sources of water pollution. They also cause thermal (heat) pollution of water.
- Synthetic detergents: Synthetic detergents used in washing and cleaning produce foam and pollute water.
- Agrochemicals: Agrochemicals like fertilizers (containing nitrates and phosphates) and pesticides (insecticides, fungicides, herbicides etc.) washed by rain-water and surface run-off pollute water.
- Oil: Oil spillage into sea-water during drilling and shipment pollute it.
- Waste heat: Waste heat from industrial discharges increases the temperature of water bodies and affects distribution and survival of sensitive species.

Effects of Water pollution:

- Oxygen demanding wastes
- Nitrogen and Phosphorous compounds
- Pathogens
- Toxic compounds

Oxygen demanding wastes:

- Organic matter which reaches water bodies is decomposed by micro-organisms present in water. For this degradation oxygen dissolved in water is consumed.
- Lower dissolved oxygen may be harmful to aquatic life especially fishes.

Nitrogen and Phosphorous compounds (Eutrophication):

- Addition of compounds containing nitrogen and phosphorous helps in the growth of algae and other plants which die and decay consume oxygen of water.
- Under anaerobic conditions foul smelling gases are produced.
- Excess growth or decomposition of plant material will change the concentration of CO2 which will further change pH of water.
- Changes in pH and Oxygen levels will affect to aquatic life.

Pathogens:

- Many waste water especially sewage contain many pathogenic (Disease causing) and non-pathogenic micro organisms and viruses.
- Water born diseases like cholera, typhoid, jaundices etc. are spread by water contaminated with sewage.

Toxic Compounds:

- Pollutants such as heavy metals, pesticides, cyanides and many organic and inorganic compounds are harmful to aquatic life.
- Pesticides contamination – Biological magnification

Toxic Compounds:

- Pollutants such as heavy metals, pesticides, cyanides and many organic and inorganic compounds are harmful to aquatic life.
- Mercury contaminated causes– Minamata Diseases
- Cadmium contaminated causes – Itai – Itai Diseases
- Nitrate Pollution contaminated causes – Blue baby syndrome
- Fluoride contaminated causes - Fluorosis

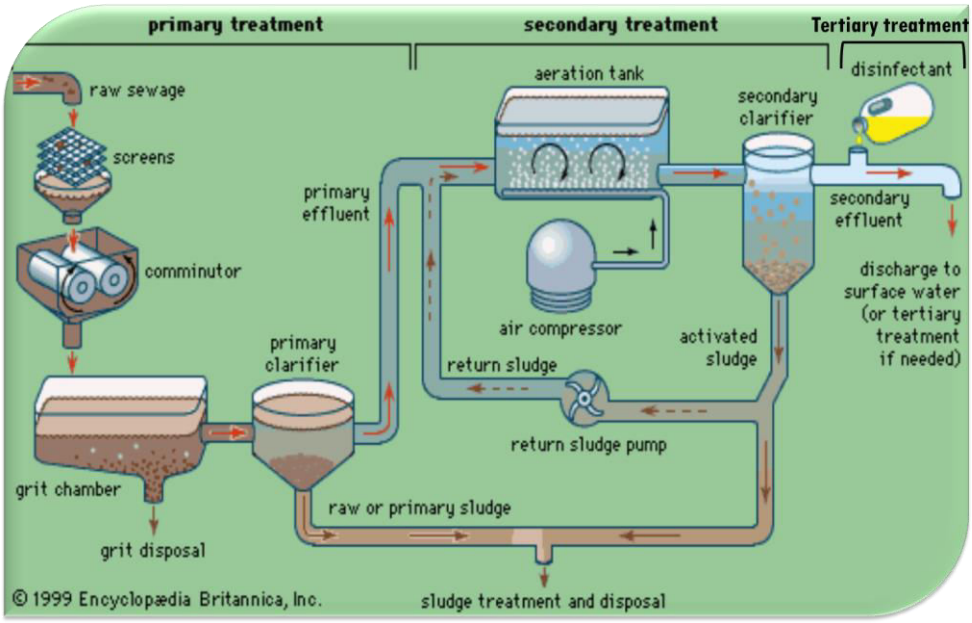
Waste Water Treatment

- The composition of municipal waste varies from place to place. Sometimes industrial wastes also mix with sewage.

- The types of treatment of waste water thus depends upon characteristics and the desired quality of water after treatment.

The wastewater treatment process are generally

- Primary treatment
- Secondary treatment
- Tertiary treatment



Primary treatment

- It is a physical process for removal of debris, large particles with help of screen.
- The waste water after screening is passed through grit chamber where sand, grit, and other solids settle down.
- The waste water is then passed through the sedimentation tank where most of the solids settle down due to gravity.
- About 35% BOD and 60 % of suspended solids are removed during primary treatment.

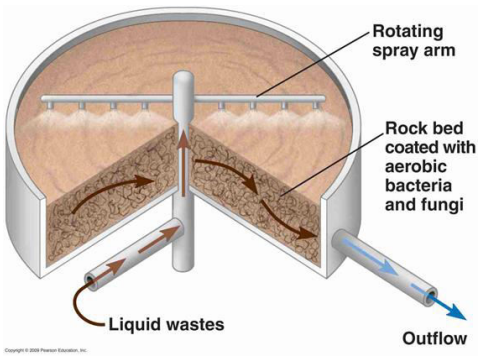
Secondary treatment

- It is a biological process which involves micro organisms.
- It removes up to 90% BOD and 90 % of Suspended solids are removed during Secondary treatment.

Following are the various approaches adopted in secondary treatment.

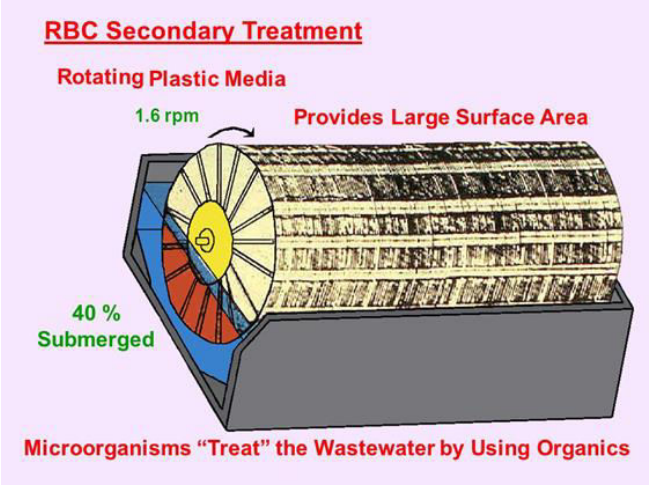
1. Trickling filter
2. Rotating biological contactor
3. Activated sludge process
4. Sludge treatment

1.Trickling filter



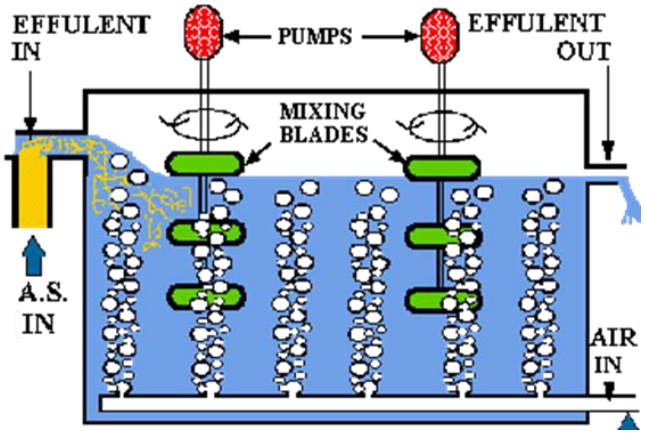
- These consist of a bed of crushed stones with slime which consists mainly microorganisms (aerobic bacteria, algae, fungi, protozoa….etc).
- Sewage is degraded by the microorganisms when it passes through the stones and is collected at bottom of filter.
- Some of the treated sewage may be recirculated along the influent. It helps in the better removal of organic matter.

2.Rotating biological contactor



- It consist of circular plastic discs which are arranged on a rotating shaft.
- Circular discs have microorganisms grown on them.
- The discs are contained in a waste water holding tank.
- About 40% area of the disc is submerged in the tank.
- The microorganisms present on disc absorb organic matter when they are in water and obtain the required oxygen when the discs are out of the water.

3.Activated sludge process



- The effluent from the trickling filter goes to aeration tank.
- Oxygen pumped into aeration tank for maintaining aerobic conditions.

- After few hour of agitation, the waste water goes to secondary settling tank.
- The sludge is produced, dewatering and disposed off.
- This can be used for land fills or disposed off in oceans.

Tertiary treatment:

Advanced sewage treatment:

- After primary and secondary treatments many undesirable substances still remain in the effluent.
- Advanced sewage treatment involves specific steps depending up on the types of substances i.e. nitrates, phosphates, pesticides, toxic metals, bacteria, viruses, colour…etc.
- Disinfection methods like chlorination, UV treatment, ozone treatment generally done to kill harmful bacteria.

SOIL POLLUTION

It is defined as the build-up in soils of persistent toxic compounds, chemicals, salts, radioactive materials, or disease causing agents, which have adverse effects on plant growth and animal health.

Soil pollution is also caused by means other than the direct addition of man-made chemicals such as agricultural runoff waters, industrial waste materials, acidic precipitates, and radioactive fallout.

Soil is the upper layer of the earth crust which is formed by weathering of rocks. Organic matter in the soil makes it suitable for living organisms. Dumping of various types of materials especially domestic and industrial wastes causes soil pollution. Domestic wastes include garbage, rubbish material like glass, plastics, metallic cans, paper, fibres, cloth rags, containers, paints, varnishes etc. Leachates from dumping sites and sewage tanks are harmful and toxic, which pollute the soil.

Sources:
Industrial wastes are the effluents discharged from chemical industries, paper and pulp mills, tanneries, textile mills, steel industries, distilleries, refineries, pesticides and fertilizer industries, pharmaceutical industries, food processing industries, cement industries, thermal and nuclear power plants, mining industries etc. Thermal power plants generate a large quantity of 'Fly ash'. Huge quantities of these wastes are dumped on soils, thus contaminating them.

Pesticides are used to kill pests that damage crops. These pesticides ultimately reach the soil and persist there for a long time. Pesticides which are persistent in nature are chlorinated hydrocarbon insecticides

e.g. DDT, HCH, endrin, lindane, heptachlor, endosulfan etc. Residues of these pesticides in the soils have long term effects especially under the temperate conditions.

Industrial wastes also contain some organic and inorganic compounds that are refractory and non-biodegradable. Industrial sludge may contain various salts, toxic substances, metals like mercury, lead, cadmium, arsenic etc. Agrochemicals released with the wastes of pesticide and fertilizer factories or during agricultural practices also reach the soil and pollute it.

Soil also receives excreta from animals and humans. The sewage sludge contains many pathogenic organisms, bacteria, viruses and intestinal worms which cause pollution in the soil.

The sources of radioactive substances in soil are explosion of radioactive devices, radioactive wastes discharged from industries and laboratories, aerial fall out etc. Isotopes of radium, uranium, thorium, strontium, iodine, caesium and of many other elements reach the soil and persist there for a long time and keep on emitting radiations.

Effects of Soil Pollution

Sewage and industrial effluents which pollute the soil ultimately affect human health. Various types of chemicals like acids, alkalis, pesticides, insecticides, weedicides, fungicides, heavy metals etc. in the industrial discharges affect soil fertility by causing changes in physical, chemical and biological properties.

Some of the persistent toxic chemicals inhibit the non-target organisms, soil flora and fauna and reduce soil productivity. These chemicals accumulate in food chain and ultimately affect human health. Indiscriminate use of pesticides specially is a matter of concern.

Sewage sludge has many types of pathogenic bacteria, viruses and intestinal worms which may cause various types of diseases. Decomposing organic matter in soil also produces toxic vapours.

Radioactive fallout on vegetation is the source of radio-isotopes which enter the food chain in the grazing animals. Some of these radio isotopes replace essential elements in the body and cause abnormalities e.g. strontium-90 instead of calcium gets deposited in the bones and tissues. The bones become brittle and prone to fracture.

Radioisotopes which attach with the clay become a source of radiations in the environment.

Nitrogen and phosphorus from the fertilizers in soil reach nearby water bodies with agricultural run-off and cause eutrophication. Chemi-cals or their degradation products from soil may percolate and con-taminate ground-water resources

Control of Soil Pollution

(i) Effluents should be properly treated before discharging them on the soil.

(ii) Solid wastes should be properly collected and disposed off by appropriate method.

(iii) From the wastes, recovery of useful products should be done.

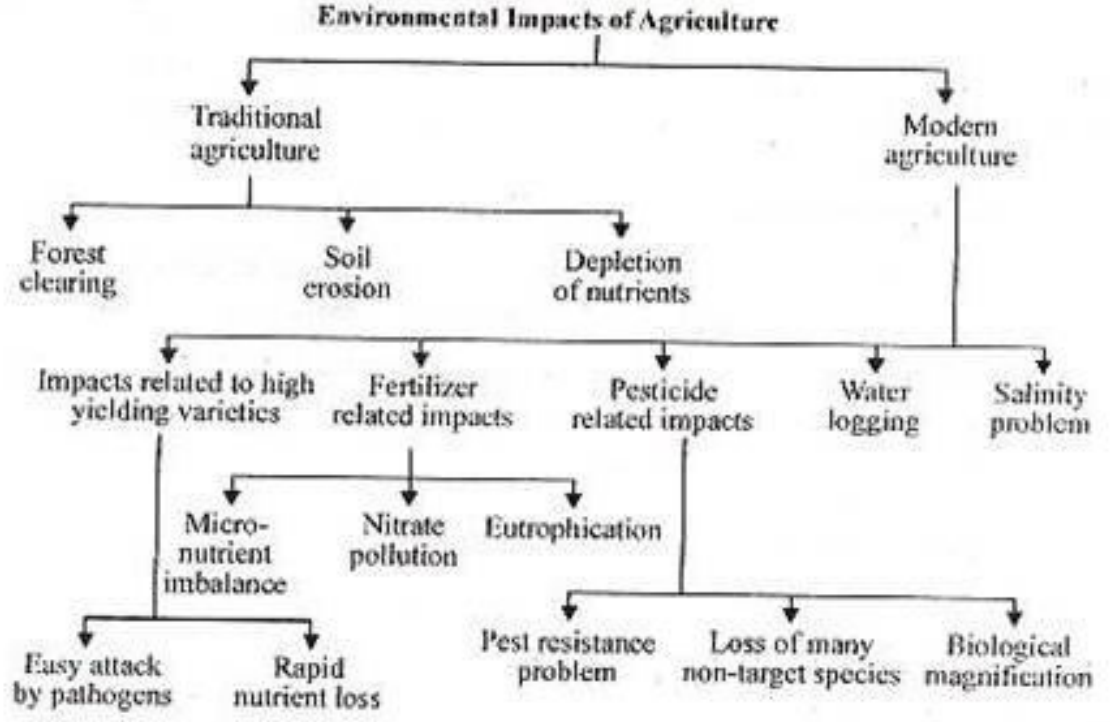
(iv) Biodegradable organic waste should be used for generation of biogas.

(v) Cattle dung should be used for methane generation. Night-soil (human faeces) can also be used in the biogas plant to produce inflammable methane gas.

(vi) Microbial degradation of biodegradable substances is also one of the scientific approaches for reducing soil pollution.

IMPACTS OF MODERN AGRICULTURE

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



A Layout of Environmental Impacts of Agriculture

(i) Impacts related to high yielding varieties (HYV): The uses of HYVs encourage monoculture i.e. the same genotype is grown over vast areas. In case of an attack by some pathogen, there is total devastation of the crop by the disease due to exactly uniform conditions, which help in rapid spread of the disease.

(ii) Fertilizer related problems:

(a) Micronutrient imbalance: Most of the chemical fertilizers used in modern agriculture have nitrogen, phosphorus and potassium (N, P, K) which are essential macronutrients. Farmers usually use these fertilizers indiscriminately to boost up crop growth. Excessive use of fertilizers cause micronutrient imbalance.

(b) Nitrate Pollution: Nitrogenous fertilizers applied in the fields often leach deep into the soil and ultimately contaminate the ground water. The nitrates get concentrated in the water and when their concentration exceeds 25 mg/L, they become the cause of a serious health hazard called "Blue Baby Syndrome" or methaemoglobinemia. This disease affects the infants to the maximum extent causing even death.

(c) Eutrophication: Excessive use of N and P fertilizers in the agricultural fields leads to another problem, which is not related to the soil, but relates to water bodies like

lakes. A large proportion of nitrogen and phosphorus used in crop fields is washed off and along with runoff water reach the water bodies causing over nourishment of the lakes, a process known as Eutrophication (eu=more, trophic=nutrition). Due to eutrophication the lakes get invaded by algal blooms. These algal species grow very fast by rapidly using up the nutrients.

They are often toxic and badly affect the food chain. The algal species quickly complete their life cycle and die thereby adding a lot of dead organic matter. The fishes are also killed and there is a lot of dead matter that starts getting decomposed. Oxygen is consumed in the process of decomposition and very soon the water gets depleted of dissolved oxygen. This further affects aquatic fauna and ultimately anaerobic conditions are created where only pathogenic anaerobic bacteria can survive. Thus, due to excessive use of fertilizers in the agricultural fields the lake ecosystem gets degraded. This shows how an unmindful action can have far reaching impacts.

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

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

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

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

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

(v) Salinity problem: At present one third of the total cultivable land area of the world is affected by salts. In India about seven million hectares of land are estimated to be salt—affected which may be saline or sodic. Saline soils are characterized by the accumulation of soluble salts like sodium chloride, sodium sulphate, calcium chloride, magnesium chloride etc.

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.

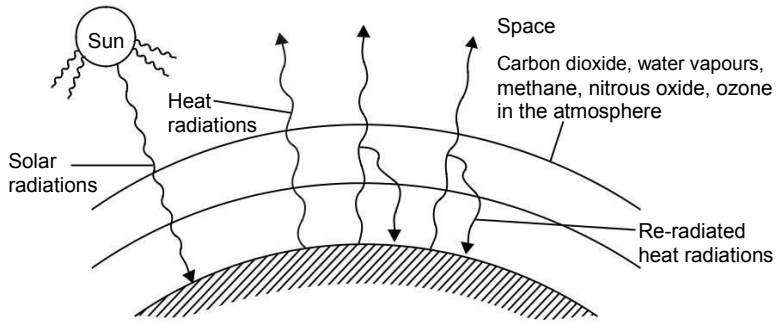
GLOBAL ENVIRONMENTAL PROBLEMS

Climate is the average weather of an area. It is the general weather conditions, seasonal variations and extremes of weather in a region. Such conditions which average over a long period- at least 30 years is called climate.

Anthropogenic (man-made) activities are upsetting the delicate balance that has established between various components of the environment. Green house gases are increasing in the atmosphere resulting in increase in the average global temperature
This may upset the hydrological cycle, result in floods and droughts in different regions of the world, cause sea level rise, changes in agriculture productivity, famines and death of humans as well as live stock.

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 Gases

The major greenhouse gases are carbon dioxide, ozone, methane, nitrous oxide, chlorofluorocarbons (CFCs) and water vapours.

1. Carbon dioxide

- It contributes about 55% to global warming from green house gases produced by human activity. Industrial countries account for about 76% of annual emissions.
- The main sources are fossil fuel burning (67%) and deforestation, other forms of land clearing and burning (33%).
- CO2 stays in the atmosphere for about 500 years.

2. Chlorofluorocarbons (CFCs)

- These are believed to be responsible for 24% of the human contribution to greenhouse gases.
- They also deplete ozone in the stratosphere. The main sources of CFCs include leaking air conditioners and refrigerators, evaporation of industrial solvents, production of plastic foams, aerosols, propellants etc.
- CFCs take 10-15 years to reach the stratosphere and generally trap 1500 to 7000 times more heat per molecule than CO2 while they are in the troposphere.

3. Methane (CH_4)

- It accounts for 18% of the increased greenhouse gases.
- Methane is produced when bacteria break down dead organic matter in moist places that lack oxygen such as swamps, natural wetlands, paddy fields, landfills and digestive tracts of cattle, sheep and termites.
- Methane stays in the at-mosphere for 7-10 years. Each methane molecule traps about 25 times as much heat as a CO_2 molecule.

4.Nitrous Oxide (N_2O)

- It is responsible for 6% of the human input of green house gases.
- Besides trapping heat in the troposphere it also depletes ozone in the stratosphere. It is released from nylon products, from burning of biomass and nitrogen rich fuels (especially coal) and from the break down of nitrogen fertilizers in soil, livestock wastes and nitrate contaminated ground water.
- Its life span in the troposphere is 140-190 years and it traps about 230 times as much heat per molecule as CO_2.

Impacts of Enhanced 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 nanometers 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 5: Environmental Policy, Legislation & EIA

FOREST (CONSERVATION) ACT, 1980

The salient features of the Act are as follows:

The State Govt. has been empowered under this Act to use the forests only for forestry purposes. If at all it wants to use it in any other way, it has to take prior approval of central Government, after which it can pass orders for declaring some part of reserve forest for non-forest purposes (e.g mining) or for clearing some naturally growing trees and replacing them by economically important trees (reforestation).
It makes provision for conservation of all types of forests and for this purpose there is an Advisory committee which recommends funding for it to the Central Government.
Any illegal non-forest activity within a forest area can be immediately stopped under this Act.
Non-forest activities include clearing of forest land for cultivation of any type of plants/crops or any other purpose (except re-afforestation). However, some construction work in the forest for wildlife or forest management is exempted from non-forest activity (e.g. fencing, making water-holes, trench, pipelines, check posts, wireless communication etc.)

1992 Amendment in the Forest Act

- In 1992, some amendment was made in the Act which made provisions for allowing some non-forest activities in forests, without cutting trees or limited cutting with prior approval of Central Govt. These activities are setting of transmission lines, seismic surveys, exploration, drilling and hydroelectric projects. The last activity involves large scale destruction of forest, for which prior approval of the Centre is necessary.
- Wildlife sanctuaries, National Parks etc. are totally prohibited for any exploration or survey under this Act without prior approval of Central Govt. even if no tree-felling is involved.
- Cultivation of tea, coffee, spices, rubber and plants which are cash-crops, are included under non-forestry activity and not allowed in reserve forests.
- Even cultivation of fruit-bearing trees, oil-yielding plants or plants of medicinal value in forest area need to be first approved by the Central Govt. This is because newly introduced species in the forest area may cause an imbalance in the ecology of the forest. If the species to be planted is a native species, then no prior clearance is required.
- Tusser cultivation (a type of silk-yielding insect) in forest areas by tribals as a means of their livelihood is treated as a forestry activity as long as it does not involve some specific host tree.
- like Asan or Arjun. This is done in order to discourage monoculture practices in the forests which are otherwise rich in biodiversity.
- Plantation of mulberry for rearing silkworm is considered a non-forest activity. The reason is same as described above.
- Mining is a non-forestry activity and prior approval of Central Govt. is mandatory. The Supreme Court in a case T.N. Godavarman Thirumulkpad Vs. Union of India (1997) directed all on-going mining activity to be ceased immediately in any forest area of India if it had not got prior approval of Central government.
- Removal of stones, bajri, boulder etc from river-beds located within the forest area fall under non-forest activity.
- Any proposal sent to central govt. for non-forest activity must have a cost-benefit analysis and Environmental Impact statement (EIS) of the proposed activity with reference to its eco-logical and socio-economic impacts.

- Thus, the Forests (Conservation) Act has made ample provisions for conservation and protection of forests and prevent deforestation

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WATER (PREVENTION AND CONTROL OF POLLUTION) ACT, 1974

It provides for maintaining and restoring the wholesomeness of water by preventing and controlling its pollution. Pollution is defined as such contamination of water, or such alteration of the physical, chemical or biological properties of water, or such discharge as is likely to cause a nuisance or render the water harmful or injurious to public health and safety or harmful for any other use or to aquatic plants and other organisms or animal life.

The definition of water pollution has thus encompassed the entire probable agents in water that may cause any harm or have a potential to harm any kind of life in any way.

The salient features and provisions of the Act are summed up as follows:

- It provides for maintenance and restoration of quality of all types of surface and ground water.

- It provides for the establishment of Central and State Boards for pollution control.

- It confers them with powers and functions to control pollution
- The Central and State Pollution Control Boards are widely represented and are given comprehensive powers to advise, coordinate and provide technical assistance for prevention and control of pollution of water.

- The Act has provisions for funds, budgets, accounts and audit of the Central and State Pollution Control Boards.

- The Act makes provisions for various penalties for the de-faulters and procedure for the same.

The main regulatory bodies are the Pollution Control Boards, which have been, conferred the following duties and powers:

Central Pollution Control Board (CPCB):

- It advises the central govt. in matters related to prevention and control of water pollution.
- Coordinates the activities of State Pollution Control Boards and provides them technical assistance and guidance.
- Organizes training programs for prevention and control of pollution.
- Organizes comprehensive programs on pollution related is-sues through mass media.
- Collects, compiles and publishes technical and statistical data related to pollution.
- Prepares manuals for treatment and disposal of sewage and trade effluents.
- Lays down standards for water quality parameters.
- Plans nation-wide programs for prevention, control or abatement of pollution.
- Establishes and recognizes laboratories for analysis of water, sewage or trade effluent sample.

The State Pollution Control Boards also have similar functions to be executed at state level and are governed by the directions of CPCB.

- The Board advises the state govt. with respect to the location of any industry that might pollute a stream or a well.
- It lays down standards for effluents and is empowered to take samples from any stream, well or trade effluent or sewage passing through an industry.
- The State Board is empowered to take legal samples of trade effluent in accordance with the procedure laid down in the Act. The sample taken in the presence of the occupier or his agent is divided into two parts, sealed, signed by both parties.
- and sent for analysis to some recognized lab. If the samples do not conform to the prescribed water quality standards (crossing maximum permissible limits), then 'consent' is re-fused to the unit.
- Every industry has to obtain consent from the Board (granted for a fixed duration) by applying on a prescribed Proforma providing all technical details, along with a prescribed fee fol-lowing which analysis of the effluent is carried out.
- The Board suggests efficient methods for utilization, treatment and disposal of trade effluents.
- The Act has made detailed provisions regarding the power of the Boards to obtain information, take trade samples, restrict new outlets, restrict expansion, enter and inspect the units and sanction or refuse consent to the industry after effluent analysis.
- While development is necessary, it is all the more important to prevent pollution, which can jeopardize the lives of the people. Installation and proper functioning of effluent treatment plants (ETP) in all polluting industries is a must for checking pollution of water and land. Despite certain weaknesses in the Act, the Water Act has ample provisions for preventing and controlling water pollution through legal measures

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THE AIR (PREVENTION AND CONTROL OF POLLUTION) ACT, 1981

Salient features of the act are as follows:

- The Act provides for prevention, control and abatement of air pollution.
- In the Act, air pollution has been defined as the presence of any solid, liquid or gaseous substance (including noise) in the atmosphere in such concentration as may be or tend to be harmful to human beings or any other living creatures or plants or property or environment.
- Noise pollution has been inserted as pollution in the Act in 1987.
- Pollution control boards at the central or state level have the regulatory authority to implement the Air Act. Just parallel to the functions related to Water (Prevention and Control of Pollution) Act, the boards performs similar functions related to improvement of air quality. The boards have to check whether or not the industry strictly follows the norms or standards laid down by the Board under section 17, regarding the discharge of emission of any air pollutant. Based upon analysis report consent is granted or refused to the industry.
- Just like the Water Act, the Air Act has provisions for defining the constitution, powers and function of Pollution Control Boards, funds, accounts, audit, penalties and procedures.
- Section 20 of the Act has provision for ensuring emission standards from automobiles. Based upon it, the state govt. is empowered to issue instructions to the authority incharge of registration of motor vehicles (under Motor Vehicles Act, 1939) that is bound to comply with such instructions.

- As per Section 19, in consultation with the State Pollution Control Board, the state government may declare an area within the state as "air pollution control area" and can prohibit the use of any fuel other than approved fuel in the area causing air pollution. No per-son shall, without prior consent of State Board operate or establish any industrial unit in the "air pollution control area".

The Water and Air Acts have also made special provisions for appeals. Under Section 28 of Water Act and Section 31 of Air Act, a provision for appeals has been made. An Appellate Authority consisting of a single person or three persons appointed by the Head of the State, Governor is constituted to hear such appeals as filed by some aggrieved party (industry) due to some order made by the State Board within 30 days of passing the orders.
The Appellate Authority after giving the appellant and the State Board an opportunity of being heard, disposes off the appeal as expeditiously as possible

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THE ENVIRONMENT (PROTECTION) ACT, 1986

The Act came into force on Nov. 19, 1986, the birth anniversary of our Late Prime Minister Indira Gandhi, who was a pioneer of environ-mental protection issues in our country. The Act extends to whole of India.
Some terms related to environment have been described as follows in the Act:

- Environment includes water, air and land and the inter-relationships that exists among and between them and human beings, all other living organisms and property.

- Environmental pollution means the presence of any solid, liquid or gaseous substance present in such concentration, as may be, or tend to be, injurious to environment.

- Hazardous Substance means any substance or preparation which by its physicochemical properties or handling is liable to cause harm to human beings, other living organisms, property or environment

The Act has given powers to the Central Government to take measures to protect and improve environment while the state governments coordinate the actions. The most important functions of Central Govt. under this Act include setting up of:

- The standards of quality of air, water or soil for various areas and purposes.

- The maximum permissible limits of concentration of various environmental pollutants (including noise) for different areas.

- The procedures and safeguards for the handling of hazardous substances.

- The prohibition and restrictions on the handling of hazard-ous substances in different areas.

- The prohibition and restriction on the location of industries and to carry on process and operations in different areas.

- The procedures and safeguards for the prevention of accidents which may cause environmental pollution and providing for remedial measures for such accidents.

- The power of entry and inspection, power to take sample etc. under this Act lies with the Central Government or any officer empowered by it.

Under the Environmental (Protection) Rules, 1986 the State Pollution Control Boards have to follow the guidelines provided under Schedule VI, some of which are as follows:

- They have to advise the Industries for treating the waste wa-ter and gases with the best available technology to achieve the prescribed standards
- The industries have to be encouraged for recycling and reus-ing the wastes.
- They have to encourage the industries for recovery of biogas, energy and reusable materials.
- While permitting the discharge of effluents and emissions into the environment, the State Boards have to take into account the assimilative capacity of the receiving water body.
- The Central and State Boards have to emphasize on the im-plementation of clean technologies by the industries in order to increase fuel efficiency and reduce the generation of envi-ronmental pollutants.

The Environment (Protection) Act, 1986 has also made provi-sion for environmental Audit as a means of checking whether or not a company is complying with the environmental laws and regulations. Thus, ample provisions have been made in our country through law for improving the quality of our environment.

Biomedical Waste (Management and handling) rules, 1998:

Biomedical waste is also known as Hospital waste which is generated during the diagnosis, treatment, immunization of human beings or animals; in research activities or testing of biological aspects. It may also include wastes like anatomical waste, culture waste, discarded medicines and chemical wastes. It is also in the form of disposable syringes, broken glasses, bandages, body fluids, human excreta etc .

It has been roughly estimated that of the 4 kg of biomedical waste generated in a hospital at least 1 kg would be infected. Surveys carried out by various agencies show that due attention is not given to Biomedical waste management.

After the notification of the Bio-medical Waste (Handling and management) Rules, 1998 establishments are slowly streamlining the process of waste collection, segregation, treatment, and disposal.

The biomedical handling rules will apply to hospitals, Nursing Homes, Veterinary Hospitals, animal Houses, Pathological labs and Blood Banks.

Management of Biomedical waste:

- Producers who are generating the bio-medical waste need to install an appropriate facility in their premises to ensure that biomedical waste should be collected in accordance with Schedule – I.
- The biomedical waste need to be segregated into containers or bags at the point of generation in accordance with Schedule – II, prior to its storage, transportation, treatment and disposal.
- The containers shall be labeled according to Schedule - III.

- The biomedical waste which is generated by means of various activities shall be handled without any adverse effects to the human health and the environment.

INTERNATIONAL CONVENTIONS / PROTOCOLS

Convention: large formal meeting of people with the same interest or work.
Protocol: The rules about what you must do and how you behave in an official situation.

The objectives of the International Conventions are to stabilize the Green House Gas concentrations in the atmosphere to certain levels to prevent dangerous human interference with the climate system of the world.

EARTH SUMMIT:
The United Nations Conference on Environment and Development (UNCED), also known as the Rio Summit, Rio Conference, Earth Summit (Portuguese) was a major conference held in Rio de Janeiro from 3 June to 14 June 1992. Totally 172 Governments were participated with their heads and representatives, NGO's accounting 17000 people.
The issues included:

- Systematic scrutiny of patterns of production of Toxic components such as lead in gasoline.
- Alternative sources of energy or replace the use of fossil fuel which are linked to global climatic changes.
- by introducing new public transport system in order to reduce vehicle emissions in cities.
- Alarming the growing scarcity of water and has been decided to come out with proper utilization methodologies.
- not to carryout any activities on lands that would cause environmentdegradation.

MONTREAL PROTOCOL:

Several meetings have taken place to address the ozone layer depletion problem. The well known meeting was held in Montreal on 16-09-1987 and the agreement signed is called the Montreal Protocol, which set a timetable to phase out of CFCs as well as halogens which contain bromine and 96 harmful chemicals in the Protocol subject the schedules.

The Montreal Protocol on substances that deplete the Ozone Layer is an international treaty designed to protect the ozone layer by phasing out the production of numerous substances believed to be responsible for ozone depletion. The treaty was opened for signature on September 16, 1987, and entered into force on January 1, 1989, followed by a first meeting in Helsinki (Finland), May 1989.
Since then, it has undergone seven revisions, in 1990 (London), 1991 (Nairobi capital of Kenya), 1992 (Copenhagen, capital of Denmark), 1993 (Bangkok in Thailand, SE Asia), 1995 (Vienna, capital of Austria), 1997 (Montreal, Canada), and 1999 (Beijing, china).
After implementing the schedules, following are the identified advantages of Montreal protocol: the highest calculated level of consumption of CFCs was 16,255 metrictons in 1988. Substances were used chiefly as refrigerants, cleaning solvent, foam blowing agents and propellants in spray can. In 1996 the consumption level was reduced to zero and maintain at that level since.

- HCFCs have been used as one of the alternative substances for CFCs since 1996. As a result, consumption of HCFCs was reduced from around 630
- ODP (Ozone Depletion Potential) metric tons in 1996 to 383 ODP metric tons in 2004, which indicated a 40% reduction from the baseline level.
- without protocol there would be a doubling effect of Ultra violet – Beta radiations reached the earth in the northern latitudes and also the amountof ozone depleting chemicals in the atmosphere would have been 5 times greater.
- it also ensured the improved scientific understanding which can be incorporated in decisions quickly.

KYOTO PROTOCOL:

The Kyoto Protocol is a legally binding International agreement to reduce Green House Gas (GHG) emissions of 5.2% by the year 2012.
The Protocol states that "developed countries are committed, individually or jointly to ensure that the emissions of Green House Gases do not exceed amounts assigned to each country in Annexure A to the Protocol.

- The agreement specifies that all countries must follow a number of statements and some of which are as follows:
- Design and implementation of climatic change mitigation (to reduce the harmful effects of something) and adoption programmes.
- harmful effects of something) and adoption programmes.
- Preparation of a national inventory of emission removal procedures.
- Promotion of climate friendly technology transfer.
- Accounting, reporting and review to ensure the integrity (honest and the ability to do) of the protocol.

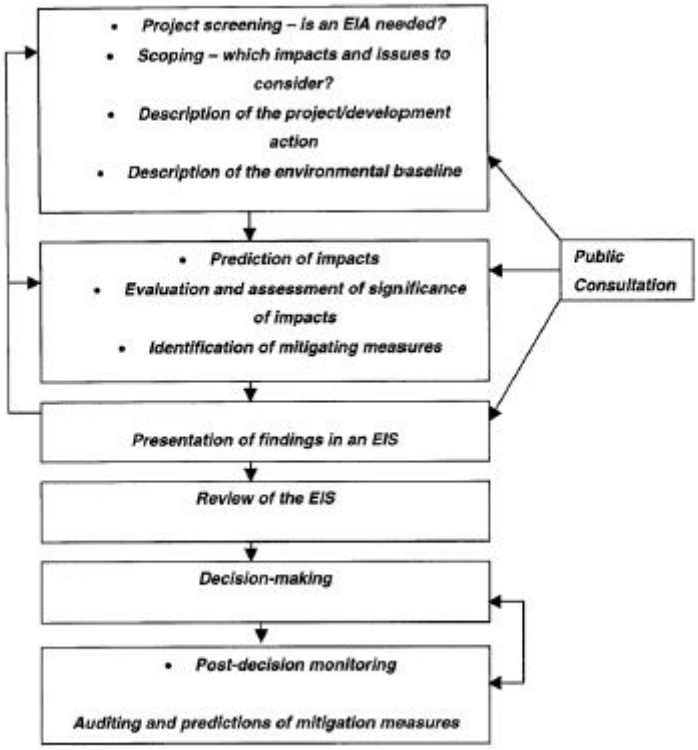
ENVIRONMENTAL IMPACT ASSESSMENT

It is a formal study process, used to predict the environmental consequences of proposed major developmental project. Such assessment may include those projects which can significantly alter the landscape and consequently disrupts and disturb the services and inhabitant of that place.
It also involves manufacturing, handling and use of hazardous materials and those projects which are to be settled nearby urban centers, near ecologically sensitive areas, hill resorts and nearby scientific and cultural heritage area:
Some of the projects are as follows:
(1) Establishment of cement industry
(2) Petroleum industry
(3) Hazardous waste treatment plant
(4) Nuclear power plant
(5) Distillaries
(6) Heavy water projects etc.

- EIA concentrates on problems and conflict of natural resources continuously that could affect the surroundings.

- It analyses the project thoroughly so that the project may not be harmful to the people, their homeland and their nearly surrounding areas.
- The predicted future problems are looked after by it and maximum attentions are paid to minimize it. EIA tries to force the problems and tries to minimize it by making a pre-design.

Steps in EIA process



EIA involves the steps mentioned below. However, EIA process is cyclical with interaction between the various steps.

EIA represents a systematic process that examines the environmental consequences of the development actions, in advance. The emphasis of a EIA is on prevention and, therefore, is more proactive than reactive in nature. The EIA process involves a number of steps, some of which are listed below:

- Project screening: This entails the application of EIA to those projects that may have significant environmental impacts. It is quite likely, however, that screening is done partly by the EIA regulations, operating in a country at the time of assessment.
- Scoping: This step seeks to identify, at an early stage, the key, significant environmental issues from among a host of possible impacts of a project and all the available alternatives.
- Consideration of alternatives: This seeks to ensure that the proponent has considered other feasible approaches, including alternative project locations, scales, processes, layouts, operating condition and the no-action option.
- Description of the project/development action: This step seeks to clarify the purpose and rationale of the project and understand its various characteristics, including the stages of development, location and processes.

- Description of the environmental baseline: This includes the establishment of both the present and future state of the environment, in the absence of the project, taking into account the changes resulting from natural events and from other human activities.
- Identification of key impacts: This brings together the previous steps with a view to ensuring that all potentially significant environmental impacts (adverse and beneficial) are identified and taken into account in the process.
- The prediction of impacts: This step aims to identify the likely magnitude of the change (i.e., impact) in the environment when the project is implemented in comparison with the situation when the project is not carried out.
- Evaluation and assessment of significance: This seeks to assess the relative significance of the predicted impacts to allow a focus on key adverse impacts. Formal definition of significance is the product of consequence and likelihood as

  Significance =consequence X Likelihood
- Mitigation: This involves the introduction of measures to avoid, reduce, remedy or compensate for any significant adverse impacts.
- Public consultation and participation: This aims to assure the quality, comprehensiveness and effectiveness of the EIAas well as to ensure that the public's views are adequately taken into consideration in the decision-making process.
- EIS presentation: This is a vital step in the process. If done badly, much good work in the EIA may be negated.
- Review: This involves a systematic appraisal of the quality of the EIS, as a contribution to the decision-making process.
- Decision-making: At this stage, decisions are made by the relevant authority of the EIS (including consultation responses) together with other material considerations as to whether to accept, defer or reject the project.
- Post-decision monitoring: This involves the recording of outcomes associated with development impacts, after the decision to proceed with the project. It can contribute to effective project management.
- Auditing: This follows monitoring and involves comparing actual outcomes with predicted outcomes, and can be used to assess the quality of predictions and the effectiveness of mitigation. It provides a vital step in the EIA learning process

ENVIRONMENT MANAGEMENT PLAN

Environmental Management Plan (EMP) is aimed to maintain the existing environmental quality.

The main objective of EMP is to investigate specific activities which are related to adverse impacts. The impacts can be first minimized by various planning activities.

Some more measures can be practiced to minimize the impacts on environment are as follows:

- The debris and unutilized construction material from construction site should be removed immediately.
- Vehicles employed should be checked for proper emissions.
- The mitigation measures shall include regular maintenance of machinery and provision of productive equipment to workers where needed.

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.