Multidisciplinary Nature of Environmental Studies

1 Introduction

The word environment is derived from the French word 'environner' which means to 'encircle or surround'.
Thus our environment can be defined as "the Social, Cultural and Physical conditions that surround, affect and influence the survival, growth and development of people, animals and plants".
It includes all factors (living and nonliving) that affect an individual organism or population at any point in the life cycle.

2 Multidisciplinary nature of environmental studies

The Environment study is a multi-disciplinary program created to promote the study of our natural surroundings.

It comprises various branches of studies like chemistry, physics, medical science, life science, geology, politics, policy studies, law, engineering, agriculture, public health, economics etc. to understand the humanity's effects on the natural world.

Life sciences including botany, zoology, microbiology, genetics, biochemistry, biotechnology help in understanding the biotic components and their interactions.

The physical and chemical structure of the biotic components and energy transfer and flow are understood with the help of basic concept of physics, chemistry, atmospheric science and oceanography.

Mathematics, statistics and computer science serve as effective

tools in environmental modeling and management.

Economics, sociology and mass communication provide the input for dealing with socio-economic aspect associated with various development activities.

A synthesis with **environmental engineering, civil engineering and chemical engineering** form the basis for various technologies dealing with the control of environmental pollution, waste treatment and development of cleaner technologies for protection of environment.

Environmental laws provide the tools for effective management and protection of the environment.

2.1 Objectives of environmental studies

1. Creating awareness about environmental problems among the students

2. Giving basic knowledge about the environment and its related problems

3. Developing an attitude of concern for the environment

4. Motivating students to participate in environment protection and environment improvement

5. Acquiring skills to help the concerned individuals in identifying and solving environmental problems.

2.2 Scope of environmental studies

1. Natural resources and their conservation and management

2. Ecology and biodiversity

3. Environment pollution and control

4. Social issues in relation to development and environment

5. Human population and environment

6. Research and development

7. Environmental journalism

8. Industry

2.3 Career options

1. Research and development in environment: Skilled environmental scientists have an important role to play in examining various environmental problems in a scientific manner and carry out RD activities for developing cleaner technologies and promoting sustainable development.

2. Green advocacy: With increasing emphasis on implementing various Acts and Laws related to environment, need for environmental lawyers has emerged, who should be able to plead the cases related to water, air, forest, wildlife, pollution and control etc.

3. Green marketing: While ensuring the quality of products with ISO mark, now there is an increasing emphasis on marketing goods that are environment friendly. Such products have ecomark or ISO 14000 certification. Environmental auditors and environmental managers would be in great demand in the coming years.

4. Green media: Environmental awareness can be spread amongst masses through mass media like television, radio, newspaper, magazine, hoardings, advertisements etc., for which environmentally educated persons are required.

5. Environmental consultancy: Many non-government organizations, industries and government bodies are engaging environmental consultants for

systematically studying and tackling environment related problems.

2.4 Importance of environmental studies

1. The importance of environmental studies is that, the current trend of environmental degradation can be reversed if people of educated communities are organized, empowered and involved in sustainable development.

2. The environment studies enlighten us, about the importance of protection and conservation of our natural resources, indiscriminate release of pollution into the environment etc.

3. Environmental studies help maintain ecological balance by providing a basic operating knowledge of Environmental system and process.

4. It gives information regarding the changes that takes place due to anthropogenic factors and helps gain skills of analyzing various Environmental systems and the effect of human activities on them.

5. It also provides knowledge about the development and utilization of energy resources.

3 Environment and its segments

Environment consists of four segments.

1. Atmosphere: Blanket of gases surrounding the earth.

2. Hydrosphere: Various water bodies present on the earth.

3. Lithosphere: Contains various types of soils and rocks on the earth.

4. Biosphere: Composed of all living organisms and their interactions with the environment.

Atmosphere: The following points highlight the vital role played by atmosphere in the survival of life in this planet.

• The atmosphere is the protective blanket of gases which is surrounding the earth. It protects the earth from the hostile environment of outer space.

• It absorbs IR radiations emitted by the sun and reemitted from the earth and thus controls the temperature of the earth

. • It allows transmission of significant amounts of radiation only in the regions of 300 – 2500 nm (near UV, Visible, and near IR) and 0.01 – 40 meters (radio waves). i.e it filters tissue damaging UV radiation below 300 nm.

•It acts as a source for CO_2 for plant photosynthesis and O_2 for respiration

• It acts as a source for N_2 for nitrogen fixing bacteria and ammonia producing plants.

• The atmosphere transports water from ocean to land.

Hydrosphere: The hydrosphere is a collective term given to all different forms of water.

It includes all types of water resources such as oceans, seas, rivers, lakes, streams, reservoirs, glaciers and ground waters.
It covers more than 75 % of the earth surface.

Lithosphere: The earth is divided in to layers.

Crust: The crust is the earth's outer skin that is accessible to human. The crust consists of rocks and soil of which the latter is the important part of lithosphere.

Mantle: It is the middle layer of the earth and is made up of different types of rocks (Igneous, sedimentary and metamorphic)

Core: It is the innermost geological layer of the Earth. It is primarily a

solid ball of rocks and minerals.

The lithosphere consists of upper mantle and the crust.

Biosphere: The biosphere or ecosphere is a global ecosystem composed of living organisms (biota) and the abiotic (nonliving) factors from which they derive energy and nutrients.

It extends from 2 kilometres into the atmosphere to 8-10 kilometers under the oceans and a few kilometres in the lithosphere
.

4 Vertical structure of atmosphere

Troposphere

- The bottom layer of the atmosphere that stretches about 11 Km
- Contains 75 % of the air
- Temperature decreases with altitude
- Storms and rainfall take place
- Made up of mostly N_2 & O_2

Stratosphere

- The second layer of the atmosphere that extends up to 50km.
- Contains 24 % of the air
- Temperature increases with altitude
- Contains ozone (O_3) layer that protects us from harmful ultraviolet rays

Mesosphere

• The third layer of the atmosphere that extends up to 80 km.

• Temperature decreases with altitude

• The coldest layer

• Here most meteors burn up

Thermosphere (ionosphere and exosphere)

• The fourth layer of the atmosphere that stretches about 1000 km.

• The hottest layer due to the ions (H^+ and He^-) that directly absorb the sun's radiation

• Temperature increases with altitude

• Where radio waves are reflected.

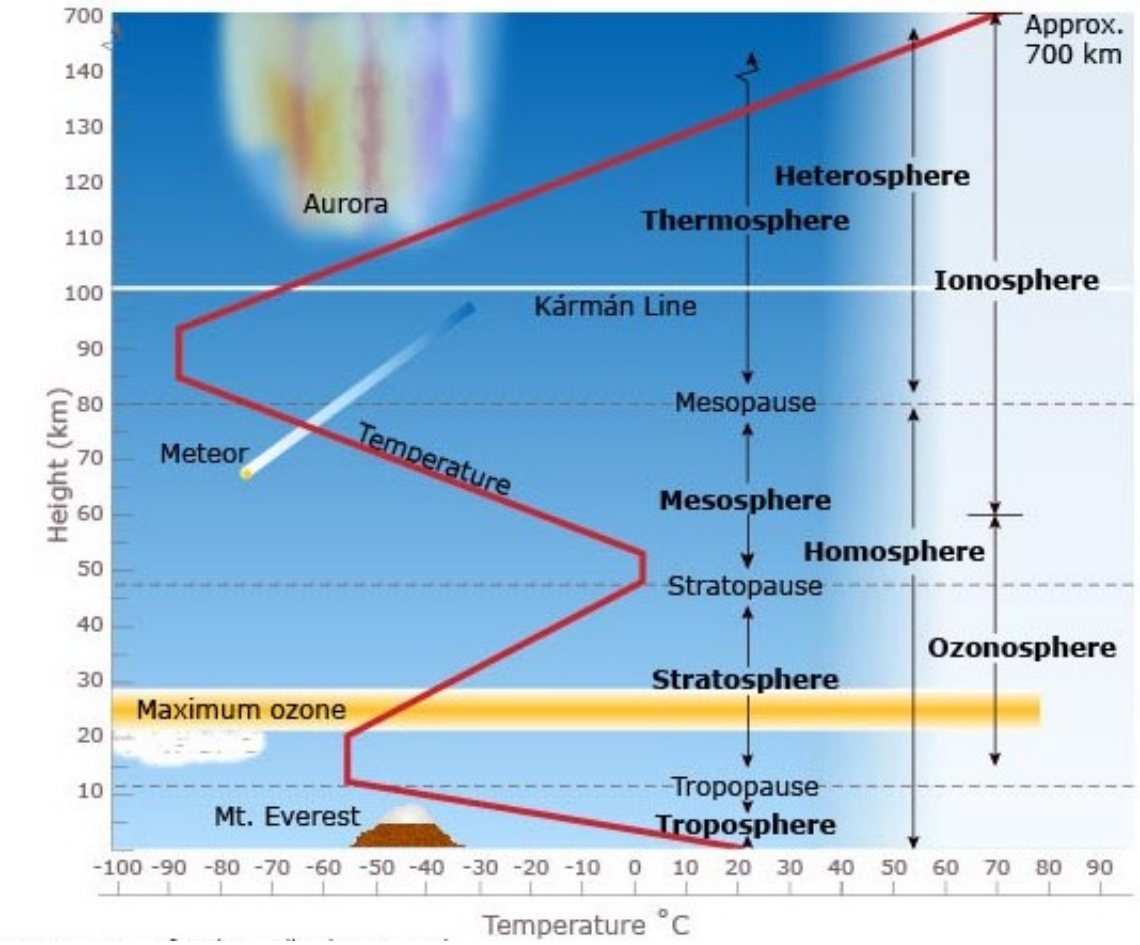

Figure 1:

Vertical structure of atmosphere

Natural Resources

What are Natural Resources?

Natural resources can be defined as the resources that exist (on the planet) independent of human actions.

These are the resources that are found in the environment and are developed without the intervention of humans. Common examples of natural resources include air, sunlight, water, soil, stone, plants, animals, and fossil fuels.

What are the Different Types of Natural Resources?

Based on the availability are two types of natural resources:

1. Renewable: resources that are available in infinite quantity and can be used repeatedly are called renewable resources. Example: Forest, wind, water, etc.

2. Non-Renewable: resources that are limited in abundance due to their non-renewable nature and whose availability may run out in the future are called non-renewable resources. Examples include fossil fuels, minerals, etc.

Renewable resource	**Nonrenewable resources**
It can be renewed as it is available in infinite quantity	Once completely consumed it cannot be renewed due to limited stock
Sustainable in nature	Exhaustible in nature
Low cost and environment-friendly	High cost and less environment-friendly
Replenish quickly	Replenish slowly or do not replenish naturally at all

The 5 Most Important Natural Resources are:

1. Air: Clean air is important for all the plants, animals, humans to survive on this planet. So it is necessary to take measures to reduce air pollution.

2. Water: 70 % of the Earth is covered in water and only 2 % of that is freshwater. Initiative to educate and regulate the use of water should be taken.

3. Soil: Soil is composed of various particles and nutrients. It helps plants grow

4. Minerals: Minerals are valuable natural resources being finite and non-renewable. They constitute the vital raw materials for many basic industries and are a major resource for development.

5. Forests: As the population increases, the demand for housing and construction projects also increases. Forests provide clean air and preserve the ecology of the world.

Biggest threats to natural resources

1. Overpopulation

2. Climate change

3. Species Extinction and Biodiversity Loss

4. Air and Water Pollution

5. Water Crisis

6. Natural Resources Drain

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Biggest threats to natural resources

1. Overpopulation

2. Climate change

3. Species Extinction and Biodiversity Loss

4. Air and Water Pollution

5. Water Crisis

6. Natural Resources Drain

7. Deforestation

8. Soil Degradation.

Conservation of Natural Resources

Conservation is the care and protection of these resources so that they can persist for future generations. It includes maintaining diversity of species, genes, and ecosystem, as well as functions of the environment, such as nutrient cycling.

Sustainable natural resources conservation is a process of rational use and skillful management and preservation of the natural environment with all its resources.

This would improve, maintain and protect the natural environment and its resources for the benefit of all mankind.

Three simple ways of conservation of natural resources include:

(a) Use them more wisely: water is often used in giant sprinkle systems to irrigate crops that shoot the water high in the air and a lot evaporates before it reaches the soil. In drip irrigation systems water is added at the

base of the plant and far less is lost to evaporation.

(b) Find substitutes: copper was the main component in wires, but now fibre optic cables are replacing some copper in internet cabling.

(c) Recycle: huge amounts of iron, copper and zinc are now recovered from old cars and recycled and reused into the making of new cars

Forest Resources

The word 'forest' is derived from the Latin word 'foris' means 'outside'.

A forest is a natural, self-sustaining community characterized by vertical structure created by presence of trees. Trees are large, generally single-stemmed, woody plants.

Forest can exist in many different regions under a wide range of conditions, but all true forests share the same physical characteristics.

The factors that influence the forest community include rainfall, fire, wind, glaciation, seismic activity, flooding, animal activity, insulation, and so on.

The direct benefits from forests are:

(a) Fuel Wood: Wood is used as a source of energy for cooking purpose and for keeping warm.

(b) Timber: Wood is used for making furniture, tool-handles, railway sleepers, matches, ploughs, bridges, boats etc.

(c) Bamboos: These are used for matting, flooring, baskets, ropes, rafts, cots etc.

(d) Food: Fruits, leaves, roots and tubers of plants and meat of forest animals form the food of forest tribes.

(e) Shelter: Mosses, ferns, insects, birds, reptiles, mammals and micro-organisms are provided shelter by forests.

(f) Paper: Wood and Bamboo pulp are used for manufacturing paper (Newsprint, stationery, packing paper, sanitary paper)

(g) Rayon: Bamboo and wood are used in the manufacture of rayon (yarns, artificial silk-fibres)

(h) Forest Products: Tannins, gums, drugs, spices, insecticides, waxes, honey, horns, musk, ivory, hides etc. are all provided by the flora and fauna of forests.

The indirect benefits from forests are:

(a) Conservation of Soil: Forests prevent soil erosion by binding the soil with the network of roots of the different plants and reduce the velocity of wind and rain — which are the chief agents causing erosion.

(b) Soil-improvement: The fertility of the soil increases due to the humus which is formed by the decay of forest litter.

(c) Reduction of Atmospheric Pollution: By using up carbon dioxide and giving off oxygen during the process of photosynthesis, forests reduce pollution and purify the environment.

(d) Control of Climate: Transpiration of plants increases the atmospheric humidity which affects rainfall and cools the atmosphere.

(e) Control of Water flow: In the forests, the thick layer of humus acts like a big sponge and soaks rain water preventing run-off, thereby preventing flash-floods. Humus prevents quick evaporation of water, thereby ensuring a perennial supply of water to streams, springs and wells.

Human Interactions with Forests:

Human are indisputably a part of most forests. With the exception of extremely inaccessible forest lands, all forests present on Earth today have

been influenced by human being for tens of thousands of years.

In many cases, forest communities have never been without the influence of human activities. Since prehistory, human beings have realized benefits from forested lands in the form of spiritual values, medicines, shelter, food, materials, fuel and more. Often, humans have sought to manipulate natural processes so as to compel forest systems to produce more of the goods and services desired by people.

Threats to forests:

Forests are vulnerable to multiple threats. Some are natural factors such as fire, insects, disease, or wind and ice storms. Others, such as climate change, invasive species and forestland conversion, are a result of human activity.

Deforestation:

Deforestation is the permanent destruction of indigenous forests and woodlands. The term does not include the removal of industrial forests such as plantations of gums or pines.

Deforestation has resulted in the reduction of indigenous forests to four-fifths of their agricultural area.

Indigenous forests now cover 21 % of the earth's land surface. The World Resources Institute regards deforestation as one of the world's most pressing land use problems.

The difference between forests and woodlands is that whereas in a forest the crowns of individual trees touch to form a single canopy, in woodland, trees are far apart, so that the canopy is open.

The rate at which deforestation is occurring is a matter of great concern. Currently, 12 million hectares of forests are cleared annually.

Almost all of this deforestation occurs in the moist forests and open woodlands of the tropics.

At this rate all moist tropical forest could be lost by the year 2050, except for isolated areas in Amazonia, the Zaire basin, as well as a few protected areas within reserves and parks.

Some countries such as Ivory Coast, Nigeria, Costa Rica, and Sri Lanka are likely to lose all their tropical forests if no conservation steps are taken.

Causes of Deforestation:

(a) Population Explosion: Population explosion poses a grave threat to the environment. Vast areas of forest land are cleared of trees to reclaim land for human settlements (factories, agriculture, housing, roads, railway tracks etc.).

Growth of population increases the demand for forest products like timber, firewood, paper and other valuable products of industrial importance, all necessitating felling of trees.

(b) Forest Fires: Fires in the forests may be due to natural calamities or human activities:

(i) Smoldering (burning slowly without flame) of the humus and organic matter forming a thick cover over the forest floor (i.e. ground fires).

(ii) Dried twigs and leaves may catch fire (i.e. surface fire)

(iii) In densely populated forests, tree tops may catch fire by heat produced by constant

rubbing against each other (i.e. crown fires).

(iv) Human activities like clearing forest for habitation, agriculture, firewood, construction of roads, railway tracks and carelessness (throwing burning cigarette stubs on dried foliage).

Fire destroys fully grown trees, results in killing and scorching of the seeds, humus, ground flora and animal life.

(c) Grazing Animals: Trampling of the forest soil in the course of overgrazing by livestock has effects such as loss of porosity of soil, soil erosion and desertification of the previously fertile forest area.

(d) Pest Attack: Forest pests like insects etc. destroy trees by eating up the leaves, boring into shoots and by spreading diseases.

(e) Natural Forces: Floods, storms, snow, lightening etc. are the natural forces which damage forests.

Effects of Deforestation:

Forests are closely related with climatic change, biological diversity, wild animals, crops, medicinal plants etc. Large scale deforestation has many far-reaching consequences:

(a) Habitat destruction of wild animals (tree using animals are deprived of food and shelter)

(b) Increased soil erosion due to reduction of vegetation cover.

(c) Reduction in the oxygen liberated by plants through photosynthesis.

(d) Increase in pollution due to burning of wood and due to reduction in Carbon dioxide fixation by plants.

(e) Decrease in availability of forest products.

(f) Loss of cultural diversity

(g) Loss of Biodiversity

(h) Scarcity of fuel wood and deterioration in economy and quality of life of people residing near forests.

(i) Lowering of the water table due to more run-off and thereby increased use of the underground water increases the frequency of droughts.

(j) Rise in Carbon dioxide level has resulted in increased thermal level of earth which in turn results in melting of ice caps and glaciers and consequent flooding of coastal areas.

Forest Conservation

Forests are called the lungs of the environment. They are a factory of oxygen and various other very important natural resources.

The environment would not survive without forests.

Forest conservation as the name suggests is the preservation and the protection of forests.

It also involves the reversal of deforestation and environmental pollution. The preservation of all natural resources is absolutely essential for the balance of our ecosystem.

Government of India introduced the Forest Conservation Act 1980. The act helps conserve forests and protects forest land. It restricts the use of forest land for commercial purposes without a thorough regulation process.

Ways to Conserve the Forest

(a) Controlled Deforestation

While deforestation cannot be avoided completely, we must look to control it. Young and immature trees should not be felled as far as possible. We must look to avoid large-scale commercial deforestation as well. Adapting practices such as clear-cutting or selective cutting will be beneficial in the long run.

(b) Protect against Forest Fires

Forest fires are the most common and deadly cause of loss of forests. They can start due to natural causes or can be accidents caused by man or even intentional in some cases. Once a fire spreads in a forest it is very difficult

to control. Precautions must be taken for such incidents. Making fire lanes, spreading chemicals to control fire, clearing out dry leaves and trees etc. are some common practices.

(c) Afforestation

This is the process by which we plant more trees in the area. We try to increase the forest cover by manual transplantation, or fresh plantation of trees. It is an attempt to balance our ecosystem to reduce the effects of deforestation and environmental pollutions of all types.

(d) Better Farming Practices

Slash and burn farming, overgrazing by cattle, shifting agriculture are all farming practices that are harmful to the environment and particularly to forests. We must keep all these practices under control.

Jhoom farming is one such practice we can employ to combat forest pollution. In the North-east areas of India, where the land is kept barren after cutting the crops, weeds and creepers and wild plants grow on this land and make it fertile again in time. Then the land is cultivated again.

How does mining affect the forests and tribal people?

(a) Mining can lead to the destruction of habitats in surrounding areas. The process begins with deforestation. The land above the mine must be cleared of all obstructions to construct the necessary infrastructure and roads for mining and transportation.

(b) Large-scale mining operations going on in the tribal areas have adversely affected the ground water table in many areas and caused pollution of nearby surface water bodies with the toxic chemicals used in the process of mining.

(c) Other impacts include removal of topsoil for open-cast mining, cumulative forest loss and pollution of soil and water sources in the adjoining areas.

(d) Deforestation at the mining area causes displacement of tribal people.

Dams and their Effects on Tribal People

(a) Construction of dams constitutes a major direct and indirect cause of forest loss and most of them have resulted in widespread human rights violation.

(b) The large reservoirs have inundated millions of hectares of forests. Tribal people displaced by the dams have had to clear forests in other areas in order to grow their crops and build their homes. It causes further forest loss.

(c) Forest loss and the major environmental changes have impacted on local people, at both the dam site and in the entire river basin.

(d) Not only are the best agricultural soils flooded by the reservoir, but major changes occur in the environment, where the river's flora and fauna begins to disappear, with strong impacts on people dependent on those resources.

Water resources

Introduction

Water resources of a country constitute one of its vital assets. India receives annual precipitation of about 4000 km^3. The rainfall in India shows very high spatial and temporal variability and paradox of the situation is that Mousinram near Cherrapunji, which receives the highest rainfall in the world, also suffers from a shortage of water during the non-rainy season, almost every year. The total average annual flow per year for the Indian rivers is estimated as 1953 km^3. The total annual replenishable groundwater resources are assessed as 432 km^3. The annual utilizable surface water and groundwater resources of India are estimated as 690 km^3 and 396 km^3 per year, respectively. With rapid growing population and improving living standards the pressure on our water resources is increasing and per capita availability of water resources is reducing day by day. Due to spatial and temporal variability in precipitation the country faces the problem of flood and drought syndrome.

Overexploitation of groundwater is leading to reduction of low flows in the rivers, declining of the groundwater resources, and salt water intrusion in aquifers of the coastal areas. Over canal-irrigation in some of the command areas has resulted in water logging and salinity. The quality of surface and groundwater resources is also deteriorating because of increasing pollutant loads from point and non-point sources. The climate change is expected to affect precipitation and water availability. So far, the data collection, processing, storage and dissemination have not received adequate attention.

Of all the planet's renewable resources, water has a unique place. It is essential for sustaining all forms of life, food production, economic development, and for general well being. It is impossible to substitute for most of its uses, difficult to de-pollute, expensive to transport, and it is truly a unique gift to mankind from nature. Water is also one of the most manageable of the natural resources as it is capable of diversion, transport, storage, and recycling. All these properties impart to water its great utility for human beings. The surface water and groundwater resources of the country play a major role in agriculture, hydropower generation, livestock production, industrial activities, forestry, fisheries, navigation, recreational activities, etc. According to National Water Policy in the planning and operation of systems, water allocation priorities should be broadly as: (i) drinking water, (ii) irrigation, (iii) hydropower, (iv) ecology, (v) agro-industries and non-agricultural industries, and (vi) navigation.

The available sources of water:

- 70 % land mass in earth under water
- Only 3 % of these are fresh water rest are saline water
- Out of this 2 % is entrapped in polar ice cap
- 1 % water is the flowing water in rivers, lakes and ground water

- Our forefathers depended on this amount and we the present generation and coming future generation will depend on this water availability India is expected to face critical levels of water stress by 2025.

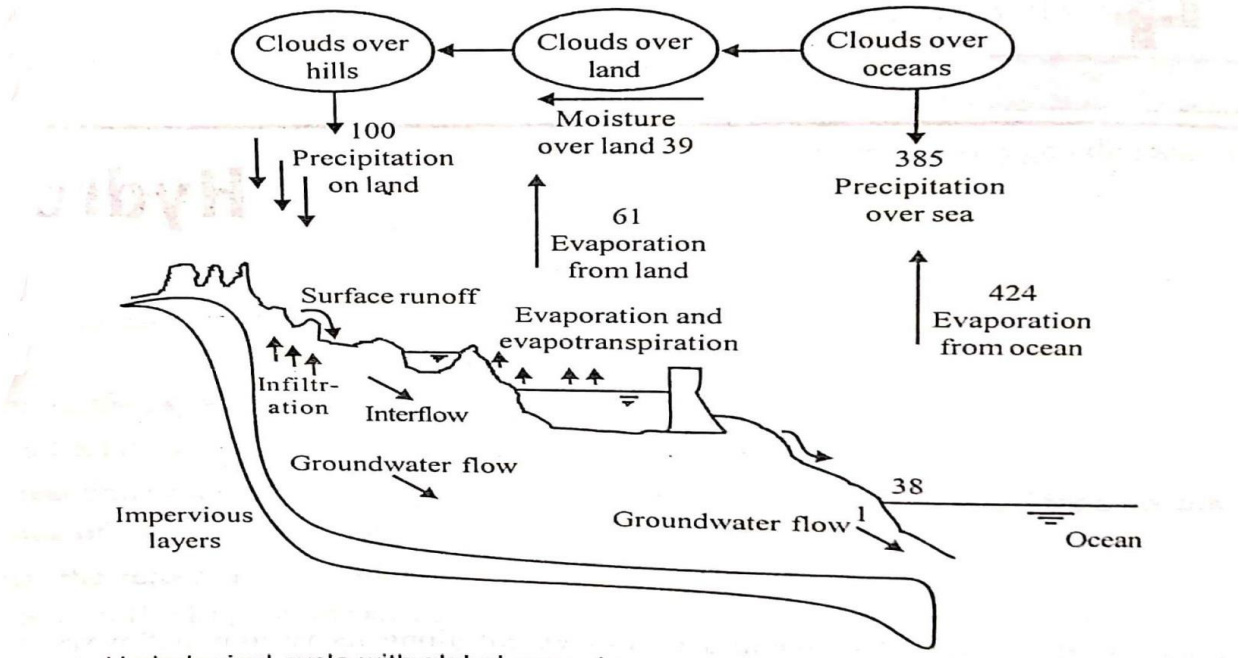
Overutilization and pollution of surface and groundwater

- With the growth of human population there is an increasing need for larger amounts of water to fulfill a variety of basic needs.
- Maximum usage of water (90%) in agriculture with the use of flowing irrigation water.
- Industry can also optimize the use of water
- Discharge of untreated sewage to inland surface water body.
- Discharge of untreated industrial effluent
- Release of agricultural run off contaminated with chemical fertilizer and pesticide

Hydrological cycle

All four spheres atmoshere,hydrosphere, lithosphere and biosphere are closely inter-linked systems and are dependent on the integrity of each other. Disturbing one of these spheres in our environment affects all the others. The linkages between them are mainly in the form of cycles. For instance, the atmosphere, hydrosphere and lithosphere are all connected through the **hydrological cycle**. Water evaporated from the hydrosphere (the seas and freshwater ecosystems), forms clouds in the atmosphere. This becomes rain, which provides moisture for the lithosphere, on which life depends.

The rain also acts on rocks as an agent of erosion and over millions of years has created soil, on which plant life grows. Atmospheric movements in the form of wind, break down rocks into soil. The most sensitive and complex linkages are those between the atmosphere, the hydrosphere and the lithosphere on the one hand, with the millions of living organisms in the biosphere on the other. All living organisms which exist on earth live only in the relatively thin layer of the lithosphere and hydrosphere that is present on the surface of land and in the water. The biosphere which they form has countless associations with different parts of the three other ‘spheres’. It is therefore essential to understand the interrelationships of the separate entities soil, water, air and living organisms, and to appreciate the value of preserving intact ecosystems as a whole.



Hydrological cycle with global annual average water balance given in units relative a value of 100 for the rate of precipitation on land.

Hydrological cycles-components

- Evaporation: The transformation of water in to water vapour at all surface at all temperature
- Transpiration: Evaporation of water from vegetative surfaces like plant foliage
- Infiltration: The movement of water into the interior of soil to the ground water regime.
- Precipitation: Water vapour forms cloud and results in precipitation in the form of rain fall and snow fall.
- Run off: The portion of precipitation percolates ground as ground water and the major portion leaves in different stream as run off.

Precipitation = Evaporation+ Transpiration + Infiltration+ Run off

Man's influence on hydrological cycle

The hydrological cycle is being modified quantitatively and qualitatively in most of the river basins of our country as a result of the developmental activities such as construction of dams and reservoirs, land use change, irrigation, etc. Such human activities affecting the hydrological regime can be classified into four major groups: (i) activities which affect river runoff by diverting water from rivers, lakes, and reservoirs or by groundwater extraction, (ii) activities modifying the river channels, e.g. construction of reservoirs and ponds, levees and river training, channel dredging, etc. (iii) activities due to which runoff and other water balance components are modified due to impacts of basin surface e.g. agricultural practices, drainage of swamps, afforestation or deforestation, urbanization, etc. and (iv) activities which may induce climate changes at regional or global scale, e.g. modifying the composition of atmosphere by increasing the 'greenhouse' gases or by increased evaporation caused by large

scale water projects. For understanding the effects appropriately, hydrological modelling approaches have to be adopted.

Water resources of India

Although India occupies only 3.29 million km^2 geographical area, which forms 2.4% of the world's land area, it supports over 15% of the world's population. India supports about 1/6th of world population, 1/50th of world's land and 1/25th of world's water resources. India also has a livestock population of 500 million, which is about 20% of the world's total livestock population. More than half of these are cattle, forming the backbone of Indian agriculture. The total utilizable water resources of the country are assessed as 1086 km^3. A brief description of surface and groundwater water resources of India is given below.

Water requirements of India

Traditionally, India has been an agriculture-based economy. Hence, development of irrigation to increase agricultural production for making the country self-sustained and for poverty alleviation has been of crucial importance for the planners. Accordingly, the irrigation sector was assigned a very high priority in the 5-year plans. Giant schemes like the Bhakra Nangal, Hirakud, Damodar Valley, Nagarjunasagar, Rajasthan Canal project, etc. were taken up to increase irrigation potential and maximize agricultural production.

Domestic use

Community water supply is the most important requirement and it is about 5% of the total water use. About 7 km^3 of surface water and 18 km^3 of groundwater are being used for community water supply in urban and rural areas. Along with the increase in population, another important change from the point of view of water supply is higher rate of urbanization. According to the projections, the higher is the economic growth, the higher would be urbanization. It is expected that nearly 61% of the population will be living in urban areas by the year 2050 in high-growth scenario as against 48% in low growth scenario.

Irrigation

The irrigated area in the country was only 22.6 million hectare (Mha) in 1950–51. Since the food production wasmuch below the requirement of the country, due attention was paid for expansion of irrigation. The ultimate irrigation potential of India has been estimated as 140 Mha. Out of this, 76 Mha would come from surface water and 64 Mha from groundwater sources. The quantum of water used for irrigation by the last century was of the order of 300 km^3 of surface water and 128 km3 of groundwater, total 428 km^3. The estimates indicate that by the year 2025, the water requirement for irrigation would be 561 km^3 for low-demand scenario and 611 km3 for high-demand scenario. These requirements are likely to further increase to 628 km^3 for low-demand scenario and 807 km3 for high-demand scenario by 2050.

Hydroelectric power

The hydropower potential of India has been estimated at 84,044 MW at 60% load factor. At the time of independence, the installed capacity of hydropower projects was 508 MW. By the

end of 1998, the installed hydropower capacity was about 22,000 MW. The status of hydropower development in major basins is highly uneven. According to an estimate, India has plans to develop 60,000 MW additional hydropower by the twelfth five-year plan. It includes 14,393 MW during the tenth five-year plan (2002–2007); 20,000 MW during eleventh (2007–2012) and 26,000 MW during the twelfth (2012–2017) five-year plans. A potential of the order of 10,000 MW is available for development of small hydropower projects in the Himalayan and sub-Himalayan regions of the country. Therefore, it is not only desirable but also a pressing need of time to draw a master plan for development of small, medium and large hydro-schemes for power generation.

Industrial water requirement

Rough estimates indicate that the present water use in the industrial sector is of the order of 15 km^3. The water use by thermal and nuclear power plants with installed capacities of 40,000 MW and 1500 MW (1990 figures) respectively, is estimated to be about 19 km^3. In view of shortage of water, the industries are expected to switch over to water efficient technologies. If the present rate of water use continues, the water requirement for industries in 2050 would be 103 km^3; this is likely to be nearly 81 km^3 if water saving technologies are adopted on a large scale.

Water resources management in India

In view of the existing status of water resources and increasing demands of water for meeting the requirements of the rapidly growing population of the country as well as the problems that are likely to arise in future, a holistic, well planned long-term strategy is needed for sustainable water resources management in India. The water resources management practices may be based on increasing the water supply and managing the water demand under the stressed water availability conditions. Data monitoring, processing, storage, retrieval and dissemination constitute the very important aspects of the water resources management. These data may be utilized not only for management but also for the planning and design of the water resources structures. In addition to these, now a days decision support systems are being developed for providing the necessary inputs to the decision makers for water resources management. Also, knowledge sharing, people's participation, mass communication and capacity building are essential for effective water resources management. Some important aspects of such strategies are described as follows.

Flood management

Among all natural disasters, floods are the most frequent to be faced in India. Floods in the eastern part of India, viz. Orissa, West Bengal, Bihar and Andhra Pradesh in the recent past, are striking examples. According to the information published by different government agencies, the tangible and intangible losses due to floods in India are increasing at alarming rate. As reported by the Central Water Commission (CWC) under the Ministry of Water Resources, Government of India, the annual average area affected by floods is 7.563 Mha. This observation is based on the data for the period 1953–2000 published in IWRS12, withvariability ranging from 1.26 Mha in 1965 to 1.75 Mha in 1978. On an average floods have affected about 33 million persons during 1953 to 2000. There is every possibility that

this figure may increase due to rapid growth of population and increased encroachments of the flood plains for habitation, cultivation and other activities. The main causes of floods in India are inadequate capacity within river banks to contain high flows, river bank erosion and silting of river beds. The additional factors are as land slides leading to obstruction of flow and change of the river course, retardation of flow due to tidal and backwater effects, poor natural drainage in the flood-prone area, cyclone and associated heavy rain storms or cloud bursts, snowmelt and glacial outbursts and dam break flows. The non-structural measures such as flood forecasting and warning are also being adopted. The flood forecasting and flood warning in India commenced in 1958, for the Yamuna river in Delhi. It has evolved to cover most of the flood-prone interstate river basins in India. The CWC has established a flood forecasting system covering 62 major rivers with more than 157 stations for issuing flood forecasts covering almost all the flood-prone states. The response of state governments towards enactment of flood plain zoning bill is not encouraging. The flood management measures have to be more focused and targeted towards the decided objectives within a stipulated time frame. For flood plain zoning, methods have to be evolved in consultation with the local bodies so that the legislation on flood plain zoning is adopted. Flood management also calls for community participation.

Farmers, professional bodies, industries and voluntary organizations have to be aware about flood management. People's participation in preparedness, flood fighting and disaster response is required. Media like radio, TV, newspapers can also play an important role in flood management. As India shares river systems with six neighbouring countries, viz. Nepal, China, Bhutan, Pakistan, Bangladesh and Myanmar, bilateral cooperation for flood management is necessary for India and the concerned country. The government of India has taken some initiatives in this regard however, more active participation is required.

Drought management

The drought-prone area assessed in the country is of the order of 51.12 Mha. The planning and management of the effects of drought appear to have a low priority due to associated randomness and uncertainty in defining the start and end of droughts. Further, most of the drought planning and management schemes are generally launched after persisting drought conditions. The traditional system of drought monitoring and estimating losses by crop cutting needs replacement with real time remote sensing, GIS, GPS and modelling techniques for ensuring transparency and quick response. Scope of losses may be extended to groundwater depletion, damage to perennial trees, plantations, orchards and depletion in fertility of livestock. Food, fodder, agricultural inputs and water banks may be established in vulnerable areas instead of their storage in surplus regions to avoid transport bottlenecks during thedrought. Robust and rainfall independent off-farm livelihood opportunities may be targeted in the drought mitigation strategy. Conjunctive use of surface and groundwater, aquifer recharge and watershed management with community participation is another important policy paradigm shift to be internalized fully.

After normal rainfall resumes there is a rapid decrease of government and public interest in drought-planning schemes. Most of the time the execution of the drought management

scheme is based on the administrative units, while planning of water resources is based on basin scale. Therefore, an integrated basin development approach is required to be developed and implemented for preparing the drought management plan before, during and after the occurrence of the drought. In this regard, there is a need for the development of the decision support systems (DSS) for the monitoring and management of the drought on basin scale utilizing the advanced capabilities of remote sensing, geographical information system and knowledge based systems. The DSS should also provide support to the decision makers for providing the information at different spatial and temporal scales. It would help them in taking the required management measures in the drought prone areas for different administrative units. In the drought-prone areas, publication campaign may be launched for water conservation with the help of electronic and print media. Necessary steps may be taken at political, administrative and technical levels to encourage people participation in the drought management for optimum utilization of the available water supply to meet the demands. Strengthening of R&D and capacity building in terms of emerging information technologies and issues of damages is also called upon to bring in resilience in the drought coping strategies.

Groundwater management

To protect the aquifers from overexploitation, an effective groundwater management policy oriented towards promotion of efficiency, equity and sustainability is required. Agricultural holdings in India are highly fragmented and the rural population density is large. The exploitation of groundwater resources should be regulated so as not to exceed the recharging possibilities, as well as to ensure social equity. The detrimental environmental consequences of over-exploitation of groundwater need to be effectively prevented by the Central and State Governments. Overexploitation of groundwater should be avoided, especially near the coasts to prevent ingress of seawater into freshwater aquifers. Clearly, a joint management approach combining government administration with active people participation is a promising solution. In critically overexploited areas, bore-well drilling should be regulated till the water table attains the desired elevation. Artificial recharge measures need to be urgently implemented in these areas. Amongst the various recharge techniques, percolation tanks are least expensive in terms of initial construction costs. Many such tanks already exist but a vast majority of these structures have silted up. In such cases, cleaning of the bed of the tank will make them reusable. Promotion of participatory action in rehabilitating tanks for recharging would go a long way in augmenting groundwater supply. Due to declining water table, the cost of extraction of groundwater has been increasing over time and wells often go dry. This poses serious financial burden on farmers. Hence, special programmes need to be designed to support these farmers. Finally, the role of government will have to switch from that of a controller of groundwater development to that of a facilitator of equitable and sustainable development.

Rainwater harvesting

Rainwater harvesting is the process to capture and store rainfall for its efficient utilization and conservation to control its runoff, evaporation and seepage. Some of the benefits of rainwater harvesting are:

- It increases water availability
- It checks the declining water table
- It is environmentally friendly
- It improves the quality of groundwater through dilution, mainly of fluoride, nitrate, and salinity, and
- It prevents soil erosion and flooding, especially in the urban areas.

Even in ancient days, people were familiar with the methods of conservation of rainwater and had practised them with success. Different methods of rainwater harvesting were developed to suit the geographical and meteorological conditions of the region in various parts of the country. Traditional rainwater harvesting, which is still prevalent in rural areas, is done by using surface storage bodies like lakes, ponds, irrigation tanks, temple tanks, etc. For example, *Kul* (diversion channels) irrigation system which carries water from glaciers to villages is practised in the Spiti area of Himachal Pradesh. In the arid regions of Rajasthan, rainwater harvesting structures locally known as *Kund* (a covered underground tank), are constructed near the house or a village to tackle drinking water problem.
In Meghalaya, *Bamboo Rainwater Harvesting* for tappingof stream and spring water through bamboo pipes to irrigate plantations is widely prevalent. The system is so perfected that about 18–20 litres of water entering the bamboo pipe system per minute is transported over several hundred meters.

Recycle and reuse of water

Another way through which we can improve freshwater availability is by recycle and reuse of water. It is said that in the city of Frankfurt, Germany, every drop of water is recycled eight times. Use of water of lesser quality, such as reclaimed wastewater, for cooling and fire fighting is an attractive option for large and complex industries to reduce their water costs, increase production and decrease the consumption of energy. This conserves better quality waters for potable uses. Currently, recycling of water is not practised on a large scale in India and there is considerable scope and incentive to use this alternative. Estimates show that recyclable water is between 103 and 177 km^3/year for low and high population projections.

People participation and capacity building

For making the people of various sections of the society aware about the different issues of water resources management, a participatory approach may be adopted. Mass communication programmes may be launched using the modern communication means for educating the people about water conservation and efficient utilization of water. Capacity building should

be perceived as the process whereby a community equips itself to become an active and well-informed partner in decision making. The process of capacity building must be aimed at both increasing access to water resources and changing the power relationships between the stakeholders. Capacity building is not only limited to officials and technicians but must also include the general awareness of the local population regarding their responsibilities in sustainable management of the water resources. Policy decisions in any water resources project should be directed to improve knowledge, attitude and practices about the linkages between health and hygiene, provide higher water supply service levels and to improve environment through safe disposal of human waste. Sustainable management of water requires decentralized decisions by giving authority, responsibility and financial support to communities to manage their natural resources and thereby protect the environment.

Advantages with reservoirs/dams

India's increasing demand for water for intensive irrigated agriculture, for generating electricity, and for consumption in urban and industrial centers, has been met by creating large dams. The major advantages are

- Water supply to intensive irrigated agricultural land
- Generation for cheap and non-polluting source of electricity
- Water supply to cash crops
- Domestic water supply
- Water supply to big industries
- Fishing activities

Problems with reservoirs/dams

Compared to advantages the disadvantages are many and these are enlisted below

- Submergence of forest land with valuable loss to biodiversity
- Fragmentation and physical transformation of rivers.
- Serious impacts on riverine ecosystems.
- Social consequences of large dams due to displacement of people.
- Water logging and salinization of surrounding lands leading to infertility of the soil.
- Dislodging animal populations, damaging their habitat and cutting off their migration routes.
- Fishing and travel by boat disrupted.
- The emission of green house gases from reservoirs due to rotting vegetation

Sustainable water management

Save water' campaigns are essential to make people everywhere aware of the dangers of water scarcity. Measure for sustainable water management

- Building several small reservoirs instead of few mega projects
- Develop small catchment dams and protect wetlands
- Soil management, micro catchment development and afforestation permits recharging of underground aquifers thus reducing the need for large dams.
- Treating and recycling municipal waste water for agricultural use.
- Preventing leakages from dams and canals.
- Preventing loss in Municipal pipes.
- Effective rain water harvesting and ground water recharging.
- Water conservation measures in agriculture such as using drip irrigation.

- Pricing water at its real value makes people use it more responsibly and efficiently and reduces water wasting.
- In deforested areas where land has been degraded, soil management by bunding along the hill slopes and making ‘nala’ plugs, can help retain moisture and make it possible to re-vegetate degraded areas.

Remarks

Water is one of the most essential natural resources for sustaining life and it is likely to become critically scarce in the coming decades, due to continuous increase in its demands, rapid increase in population and expanding economy of the country. Variations in climatic characteristics both in space and time are responsible for uneven distribution of precipitation in India. This uneven distribution of the precipitation results in highly uneven distribution of available water resources both in space and time, which leads to floods and drought affecting the vast areas of the country. Better and scientific structural and non-structural measures are required for mitigating the floods and droughts. Mathematical models are needed for forecasting the monsoon rainfall accurately, which may be utilized by the decision makers and farmers for adopting appropriate strategies for management of droughts and floods.

There is a need for increasing the availability of water and reducing its demand. For increasing the availability of water resources, there is a need for better management of existing storages and creation of additional storages by constructing small, medium and large sized dams considering the economical, environmental and social aspects. The availability of water resources may be further enhanced by rejuvenation of dying lakes, ponds and tanks and increasing the artificial means of groundwater recharge. In addition to these measures, inter basin transfer of water provides one of the options for mitigating the problems of the surplus and deficit basins. However, for inter basin transfer of water the scientific studies need to be carried out for establishing its technical and economic feasibility considering the environmental, social and eco-hydrological aspects.

Integrated and coordinated development of surface water and groundwater resources and their conjunctive use should be envisaged right from the project planning stage and should form an integral part of the project implementation. There is a need for proper management of groundwater resources, which presently require adequate inputs including manpower, financial inputs, technologies, etc. Some of the important measures which may be taken up for sustainable development of groundwater resources include improving public water supply, use of energy pricing and supply to manage agricultural groundwater draft, increasing rain-water harvesting and groundwater recharge, transfer of surface water in lieu of groundwater pumping, increasing the economic growth and reduction in dependence on agriculture and formalizing the water sector. The components of the hydrologic cycle are being affected because the hydrological processes are no longer stationary due to point and non-point changes taking place in the river basins. An accurate assessment of available surface and groundwater resources, considering the manmade changes, is needed for planning, design and operation of the water resources projects as well as for watershed

management. There should be a periodic reassessment of the surface and groundwater potential on a scientific basis, taking into consideration the quality of water available and economic viability of its extraction. Since the hydrological processes are continuous and quite complex, an accurate assessment of quantities of water simultaneously passing through all these processes is quite a difficult task. Mathematical modelling of hydrological processes would provide an opportunity to both the research hydrologists and the water resources engineers involved in developing the integrated approaches for planning, development and management of water resources projects for sustainable development as well for preserving the ecosystems.

The available information and data collected so far by different operational and field organizations, scientific groups and engineering community are inadequate for planning, development and management of the vast water resources in the country. The time series data of the hydrological and meteorological variables, the space-oriented data and relation-oriented data are generated in a fragmented. Thus, in this regard, a comprehensive, reliable and easily accessible Information System for water resources data is a pre-requisite.Climate change is posing a challenge before the water resources engineers. Hydrological studies are required to be taken up for assessment of water resources under changing climatic scenarios. For predicting the future climatological variables on micro, meso and macro watershed scales, a comprehensive general circulation model is required to be developed for India, giving due consideration to the global scenarios. With the rapid industrialization and increasing use of fertilizers and pesticides, the quality of surface and groundwater resources is deteriorating. The movement of pollutants in the rivers, lakes and groundwater aquifers needs to be regulated. In this regard, regular water quality monitoring programme has to be launched for identifying the areas likely to be affected because of the water quality problems. For maintaining the quality of freshwater, water quality management strategies are required to be evolved and implemented.

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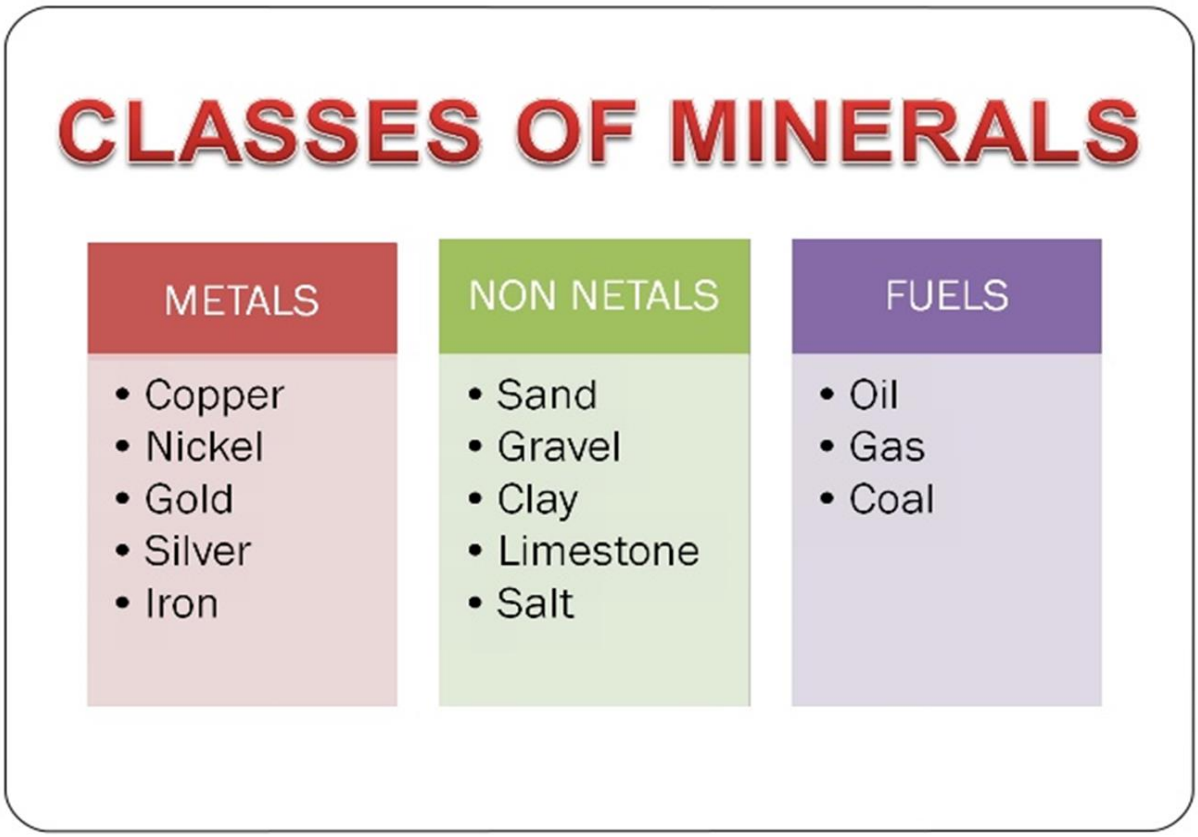
Mineral Resources

Natural resources play a vital role in supporting all activities of the life on earth. Without using any of natural resources, we cannot survive. Mineral resources are basic resources required by all societies. They are the basis for almost every product and material we use in our daily lives. They are the stuff from which a modern industrialized society is built. Essentially all are non-renewable on a human time scale. Have a limited amount of them. Have to exploit them in a sustainable fashion if we are not to run out.

Minerals are naturally occurring, inorganic, crystalline solids having a definite chemical composition and characteristic physical properties.

An ore is a mineral or combination of minerals from which a useful substance such as a metal can be extracted and used to manufacture a useful product.



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

1. Fuel Minerals: Oil, gas, coal
2. Non-metallic minerals: graphite, diamond, quartz, feldspar
3. Metallic Minerals: bauxite, chalcopyrite, hematite etc

India is the producer of 84 minerals the annual value of which is about Rs. 50,000 crores.

Types of Mineral Resources

1. **Fuel Minerals**
   i) Coal
   ii) Crude oil/petroleum
   iii) Natural gas

Fuels are used to produce energy required for all the activities in modern life.

2. **Metallic Resources**
   i) Iron ore(Hematite)-principal metallic ore in India
   ii) Lead and Zinc-batteries
   iii) Copper-Electrical
   iv) Bauxite-Aluminum
   v) Manganese and Chromite-Steel
   vi) Gold and Silver-electronics

3. **Non-metallic Resources**

i) Dolomite-$CaMg(CO_3)_2$-ingredients for glass, bricks and ceramics
ii) Lime stone-cement
iii) Mica
iv) Gypsum, plaster of paris, wall board
v) Quartz
vi) Diamond
vii) Other precious and semiprecious gem stone

Metallic minerals can be melted to obtain new products whereas non-metallic minerals do not yield new products on melting.

The main uses of minerals are as follows:

- (i) Development of industrial plants and machinery.
- (ii) Energy Source: coal, lignite, uranium.
- (iii) Construction, housing, settlements.: Iron,
- (iv) Defence equipment-weapons, armaments.
- (v) Transportation means.; Rail, Vehicle
- (vi) Communication- telephone wires, cables, electronic devices.
- (vii) Medicinal system- Ayurvedic/Allopathic System: Ag, Au,Zn
- (viii) Formation of alloys for various purposes (e.g., Bronze, Brass).
- (ix) Agriculture: fertilizers, seed dressings and fungicides (e.g.
- zineb containing zinc, Maneb-containing manganese etc.).
- (x) Jewelry: Gold, silver, platinum, diamond.

<u>Availability of different minerals in India</u>

- (a) Energy generating minerals: Coal and lignite: West Bengal, Jharkhand, Orissa, M.P., A.P.
- Uranium (Pitchblende or Uranite ore): Jharkhand, Andhra Pradesh (Nellore, Nalgonda), Meghalaya, Rajasthan (Ajmer).
- (b) Other commercially used minerals Aluminium (Bauxite ore): Jharkhand, West Bengal, Maharashtra, M.P., Tamilnadu.
- Iron (haematite and magnetite ore): Jharkhand, Orissa, M.P., A.P., Tamilnadu, Karnataka, Maharashtra and Goa.
- Copper (Copper Pyrites): Rajasthan (Khetri), Bihar, Jharkhand, Karnataka, M.P., West Bengal, Andhra Pradesh and Uttarnchal.

Iron ore: India possesses over 20% of world's total reserves of iron. Iron ore of very good quality is obtained from principal areas in Orissa and Singbhum district of Bihar. Besides there iron ore is obtained from Durg in Madhya Pradesh, Saleem in Tamil Nadu, some parts of Karnatak etc.

Bauxite: Important bauxite deposits occur in Bihar, Goa, Gujrat, Jammu and Kashmir, Karnataka, Madhya Pradesh, Odisha and Tamil Nadu

Mica: India is the largest producer of mica in the world and the largest supply comes from Bihar. In Bihar, most of the areas are Gaya and Hazirabag. Another important area is Nellore in Andhra Pradesh, some parts of Rajastan etc.

Coal: India is one of the principal producers of coal in the world. Bihar and West Bengal produce the largest quantity of good quality coal. Besides this, coal is found in Odisha, Madhya Pradesh, and Andhra Pradesh.

Petroleum: It is also called mineral oil or crude oil. It is dark, thick liquid found at a great depth under the rocks of the sea bed. We get petrol, diesel, kerosene oil, wax, Vaseline and tar when petroleum is refined. Petroleum is known as black gold. Petroleum is found at Digboi of Assam, Bombay high off the sea shore of Bombay.

Manganese: Manganese is used in the manufacture of steel. It is also used in chemicals and glass industries. India is the largest producer of manganese in the world.

Copper: It is a valuable metal. Being a good conductor of electricity, it is used for making electric wires and electric and electrical appliances.

How do we exploit mineral resources?

Surface mining: Shallow overburden removed and discarded with other material not wanted or processed (**spoil**). It is now the most common form of mining in the U.S. It is becoming even more popular (for example, in coal mining) because it is relatively inexpensive. Can be done in **open-pits** or **quarries**, by **dredging** (in water), and by **strip mining** (either area, where flat, or contour, where hilly).

Subsurface mining: Relatively deep vertical, inclined, or horizontal shafts dug underground. Disturbs much less (~10%) land than surface techniques and produces less waste material. However, it is a much more expensive and dangerous (mine collapse and inhalation diseases) technique, while also being much less efficient.

Environmental Impacts of Extracting and Using Mineral Resources

Depending on the particular resource, method of extraction, processing technology, and mode of use exploiting mineral resources can cause a large amount of land disturbance, air and water pollution, erosion, and use of energy. But we need these things to have a modern technological society.

A. Mining pollution

Mining typically results in surface disruption, loss of habitats, and water pollution. Underground mines can collapse and waste materials may pollute surrounding streams and the air. Acid (sulfuric) mine drainage often a problem if sulfate or sulfide minerals being extracted. Toxic metals (Pb, Hg, As, Cd) can be leached from their source by the action of acidic waters.

Initial processing of the ore (**milling**) often leads to large amounts of waste (**gangue**) rock being separated. Placed in open **tailings piles** that can pollute the air and water and also be a landslide hazard.

Smelting (separation from host mineral) to concentrate desired material often produces large amounts of air pollution, which can cause acid deposition and the release of toxic metals. Create **dead zones** around large smelting areas (Sudbury, Ontario). Large, short-term outlays to reduce pollution can lower long-term costs.

Environmental Impacts of Mining

- Acid Mine Drainage
- Erosion and Sedimentation
- Cyanide & Other Toxic Releases
- Dust Emissions
- Habitat Modification
- Surface and Groundwater Contamination
- Strip mining causes severe soil erosion and chemical runoff

Impact of mining

(i) Devegetation and defacing of landscape: The topsoil as well as the vegetation are removed deforestation leads to several ecological losses, increase the landscape. prone to soil erosion.

(ii) Subsidence of land: Mainly associated with underground mining which results in tilting of buildings, cracks in houses, buckling of roads, bending of rail tracks and leaking of gas from cracked pipelines leading to serious disasters.

(iii) Groundwater contamination:

Mining disturbs the natural hydrological processes and also pollutes the groundwater. Sulphur, usually present as an impurity in many ores is known to get converted into sulphuric acid

through microbial action, thereby making the water acidic. Some heavy metals also get leached into the groundwater and contaminate it posing health.

iv) Surface water pollution: The acid mine drainage often contaminates the nearby streams and lakes. Sometimes uranium, Cr, Pb, Cd, As contamination by mine wastes kill aquatic animals and creating human health hazards. Heavy metal pollution of water bodies near the mining areas is a common feature creating health hazards.

Acid drainage

Sub-surface mining frequently goes below the water table so water must be constantly pumped from the mine. Acid mine drainage results from the outflow of water from metal mines, coal mines, or other areas in which the ground has been disturbed. Metal salts, such as Fe^{+2}, are oxidized upon contact with air to more highly acidic aquo species. Sulfur containing molecules are air oxidized to sulfuric acid. Certain bacteria, called acidophiles, promote the oxidation of iron sulfides in the presence of oxygen and water.

$$2FeS_{2(s)} + 7O_{2(g)} + 2H_2O_{(l)} \longrightarrow 2Fe^{2+}_{(aq)} + 4SO_4^{2-}{}_{(aq)} + 4H^{+}_{(aq)}$$

(sulfide minerals on exposed rock surfaces react with oxygen and rainwater to produce sulfuric acid)

Toxic Inorganic Pollutants

Mining operations release heavy metals that can be extracted by water. Depending on the mine and its location, Ni, V, Cr, Mn, Cu, Pb, Zn and As can be released into the hydrosphere.

Mercury

Mercury was widely used to in California gold mines to extract the precious metal from solid ore. Between the years 1850 and 1981, more than 220,000,000 lb of mercury was used in mining in that state.

Cyanide

Cyanide salts are widely used to extract gold from finely crushed ore because they combine with about 97% of the elemental gold. Typically, the NaCN solution is sprayed on heaps of ore and the liquid extract is collected. Of course, a great deal of the toxic cyanide salt remains on the mineral partials and is washed into ground and surface water in the rain.

$$4\ Au + 8\ NaCN + O_2 + 2\ H_2O \longrightarrow 4\ NaAu(CN)_2 + 4\ NaOH$$

Once the gold has been extracted, zinc is used to recover solid gold from solution:

$2\ Au(CN) + Zn \longrightarrow 2\ Au + Zn(CN)_4^{-2}$

Arsenic

Arsenic containing minerals are exposed to surface water during mining. Arsenite ($H_2AsO_3^-$) is the more serious problem because of its high solubility in water.

Occupational health hazards

Most of the miners suffer respiratory diseases like asbestosis, silicosis, black lung etc. and skin diseases due to constant exposure to the suspended particulate matter and toxic substances.

On an average, there are 30 non-fatal but disabling accidents per ton of mineral produced and one death per 2.5 tons of mineral produced.

Besides this, the following environmental problems also arises with mining

- Mountaintop removal causes enormous damage
- Subsurface mining is harmful to human health
- Mine shaft collapses
- Inhalation of coal dust can lead to fatal black lung disease
- Costs to repair damages of mining are very high
- These costs are not included in the market prices of fossil fuels, which are kept inexpensive by government subsidies
- Mining companies must restore landscapes, but the impacts are still severe
- Looser of restrictions in 2002 allowed companies to dump rock and soil into valleys, regardless of the consequences
- Gold is treated with a Cyanide compound which produces a Gold-Cyanide complex which is soluble

Major mines causing severe Environmental problems

- i) Jaduguda Uranium Mine: , Jharkhand.exposing local people to radioactive hazards.
- (ii) Jharia coal mines: Jharkhand.underground fire leading to land subsidence and forced displacement of people.
- (iii) Sukinda chromite mines, Orissa. seeping of hexavalent chromium into river posing serious health hazard, Cr^{6+} being highly toxic and carcinogenic.
- (iv) Kudremukh iron ore mine, Karnataka.causing river pollution and threat to biodiversity.
- (v) East coast Bauxite mine, Orissa.Land encroachment and issue of rehabilitation unsettled.
- (vi) North-Eastern Coal Fields: Assam.Very high sulphur contamination of groundwater.

How can mining become more environmentally sustainable?(Preventive Measures)

It is a vital industry which contributes to the economy of many countries simultaneously it is also damaging the environment.

There are ways that mining companies can become more environmentally sustainable as outlined below.

Reduce inputs

The mining industry uses a large amount of water and land in their operations. One solution to becoming more environmentally sustainable is to reduce the input of the mine. By diverting surface water and pumping groundwater, mines can reduce both the quantity and quality of water available downstream for aquatic ecosystems and other use.

- The energy consumed by the mining sector can be modified using alternative resources like solar energy or wind power.
- By reducing the energy usage, a mine can reduce greenhouse gases and extend the life of fossil fuel reserves.

Reduce outputs

- Mining produces materials such as solid waste, mine water and air particles, all of which vary in their makeup and potential for environmental contamination.
- Waste management plans are required in order to prevent soil, air and water pollution.
- These plans are also in place to appropriately store the large volumes of waste produced at mine sites.
- To reduce waste output, environmentally friendly modern equipment can be used.

Proper waste disposal

- Correct waste disposal is vital to curbing the environmental impact of mines, as some mining companies do not dispose of their waste according to guidelines.
- Water can be reused on mining sites as grey water for washing equipment or flushing staff toilets.
- Scrap materials can be recycled or sold to companies who can reuse them in order to reduce the amount of waste produced on site.
- Improving the manufacturing process
- The efficiency of the mining process can often leave much to be desired, but improving the efficiency of this process can help towards lessening the environmental impact. This also allows companies to regulate processes which may be lacking in environmental friendliness.

Other preventive measures are

1. Top soil replacement using uncontaminated soil
2. Reintroduction of flora and fauna
3. Neutralizing acidic waters
4. Backfilling and sealing of abandoned underground mines
5. Stabilizing the slope to reduce erosion

CONCLUSION

- Mineral deposits in the earth are limited.
- We should use them carefully.
- We should not exhaust all of our resources un-thoughtfully.
- We should find some alternative to minerals.
- We should use solar, wind and water energy as an alternative to coal and petrol.

Energy Resources

Energy may be defined as the capacity to do work.

Both energy production and energy utilization are the indicators of a country's progress as it is a primary input for industrial operation.

1. **Growing Energy Needs**

   Energy consumption of a nation is usually considered as an index of its development, because almost all the development activities are directly or indirectly dependent upon energy. Power generation and energy consumption are crucial to economic development as economy of any nation depends upon availability of energy resources. There are wide disparities in per capita energy use of developed and the developing nations. With increased speed of development in the developing nations energy needs are also increasing.

- The very original 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 has also been used. Invention of steam engineers replaced the burning of wood by coal and coal was further replaced by oil.
- The oil producing has started twisting arms of the developed as well as developing countries by dictating the prices of oil and other petroleum products.
- Energy resources are primarily divided into two categories viz. renewable and non-renewable sources.
- Renewable energy resources must be preferred over the non-renewable resources.
- It is inevitable truth that now there is an urgent need of thinking in terms of alternative sources of energy, which are also termed as non-conventional energy sources which include:

1. Solar energy needs equipments such as solar heat collectors, solar cells, solar cooker, solar water heater, solar furnace and solar power plants.
2. Wind energy

3. Hydropower, Tidal energy, ocean thermal energy, geothermal energy, biomass, biogas, biofuels etc.

- The non-renewable energy sources include coal, petroleum, natural gas, nuclear energy.

2. Energy Scenario

Energy is a key input in the economic growth and there is a close link between the availability of energy and the future growth of a nation. Power generation and energy consumption are crucial to economic development.

In India, energy is consumed in a variety of forms such as fuel wood; animal waste and agricultural residues are the traditional sources of energy. These non-commercial fuels are gradually getting replaced by commercial fuels i.e. coal, petroleum products, natural gas and electricity.

Out of total energy, commercial fuels account for 60% whereas the balance 40% is coming from non-commercial fuels. Of the total commercial energy produced in the form of power or electricity,

- 69% is from coal (thermal power),
- 25% is from hydel power,
- 4% is from diesel and gas,
- 2% is from nuclear power, and
- Less than 1% from non- conventional sources like solar, wind, ocean, biomass, etc.

Petroleum and its products are the other large sources of energy. In a developing country like India, in spite of enhanced energy production, there is still shortage due to increased demand of energy. In spite of the fact that there is a phenomenal increase in power generating capacity, still there is 30% deficit of about 2,000 million units.

Policy makers are in the process of formulating an energy policy with the objectives of ensuring adequate energy supply at a minimum cost, achieving self-sufficiency in energy supplies and protecting environment from adverse impact of utilizing energy resources in an injudicious manner. The main

features of this policy are

1. Accelerated exploitation of domestic conventional energy resources, viz., oil, coal, hydro and nuclear power;
2. Intensification of exploration to achieve indigenous production of oil and gas;
3. Efficient management of demand of oil and other forms of energy;
4. To formulate efficient methods of energy conservation and management;
5. Optimisation of utilisation of existing capacity in the country
6. Development and exploitation of renewable sources of energy to meet energy requirements of rural communities;
7. Organisation of training for personnel engaged at various levels in the energy sector.
8. Government private partnership to exploit natural energy resources

3. Renewable Resources

- The resources that can be replenished through rapid natural cycles are known as renewable resource.
- These resources are able to increase their abundance through reproduction and utilization of simple substances.
- Examples of renewable resources are plants (crops and forests),and animals who are being replaced from time to time because they have the power of reproducing and maintain life cycles.
- Some examples of renewable resources though they do not have life cycle but can be recycled are wood and wood-products, pulp products, natural rubber, fibres (e.g. cotton, jute, animal wool, silk and synthetic fibres) and leather.

- In addition to these resources, water and soil are also classified as renewable resources. Solar energy although having a finite life, as a special case, is considered as a renewable resource in as much as solar stocks is inexhaustible on the human scale.

4. Non-Renewable Resources

- The resources that cannot be replenished through natural processes are known as non-renewable resources.
- These are available in limited amounts, which cannot be increased. These resources include fossil fuels (petrol, coal etc.), nuclear energy sources (e.g. uranium, thorium, etc). Metals (iron, copper, gold, silver, lead, zinc etc.), minerals and salts (carbonates, phosphates, nitrates etc.).
- Once a non-renewable resource is consumed, it is gone forever. Then we have to find a substitute for it or do without it.
- Non-renewable resources can further be divided into two categories, viz. Recyclable and non-recyclable

4.1 Recyclable resources

These are non-renewable resources, which can be collected after they are used and can be recycled. These are mainly the non-energy mineral resources, which occur in the earth's crust (e.g. ores of aluminium, copper, mercury etc.) and deposits of fertilizer nutrients (e.g. phosphate sock and potassium and minerals used in their natural state (asbestos, clay, mica etc.)

4.2 Non-recyclable resources

These are non-renewable resources, which cannot be recycled in any way. Examples of these are fossil fuels and nuclear energy sources (e.g. uranium, etc) which provide 90 per cent of our energy requirements.

5. Use of Alternate Energy Sources

There is a need to develop renewable energy sources which are available and could be utilized (solar or wind) or the sources which could be created and utilized (bio-mass). The main renewable energy sources for India are solar, wind, hydel, waste and bio-mass. Bio-mass are resources which are agriculture related like wood, bagasse, cow dung, seeds, etc.

5.1. Solar energy

India being a tropical country has potential to use solar energy on commercial bases. According to estimates, 35 MW of power could be generated from one sq km. With such potential, solar energy has bright future as energy source for the development of the country. Initial cost is the biggest limitation which has led to the low realization of its potential. For solar energy to become one of the front runners, it will require lot of research, cheap technology and low capital.

The energy that we get directly from the sun is called solar energy. The nuclear fusion reactions occurring inside the sun release enormous amount of energy in the form of heat and light. The solar energy received by the near earth space is approximately1.4 kJ/m2/s known as solar constant.

Methods of Harvesting Solar Energy

Solar cells (or) photovoltaic cells (or) PV cells

Solar heat collectors

Solar water heater

Solar cells

Solar cells consist of a p-type semiconductor (such as Si doped with B) and n-type semi-conductor (Si doped with P). When the solar rays fall on the top layer of p-type semi-conductor, the electrons from the valence band get promoted to the conduction band and cross the p-n junction into n-type semi-conductor.There by potential difference between two layers is created, which causes flow of electrons (ie.,an electric current)

Solar cell Uses

Used in calculators, electronic watches. Street lights, water pumps to run radios and TVs.

Solar Battery

When a large number of solar cells are connected in series it form a solar battery.Solar battery produce more electricity which is enough to run water pump, to run street-light, etc., They are used in remote areas where conventional electricity supply is a problem.

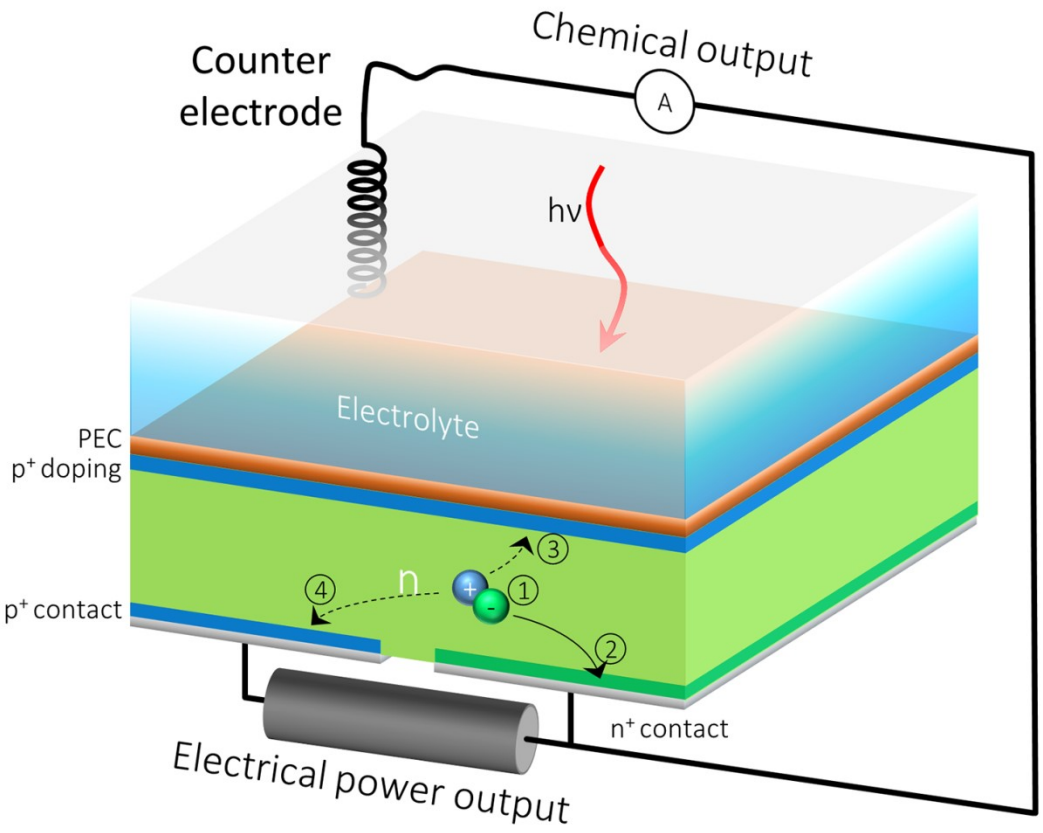


Fig. Solar cell working principle

Solar heat collectors

Solar heat collectors consists of natural materials like stones, bricks, (or) materials like glass, which can absorb heat during the day time and release it slowly at night.

Solar heat collector Uses

Used in cold places, where houses are kept in hot condition using solar heat collectors

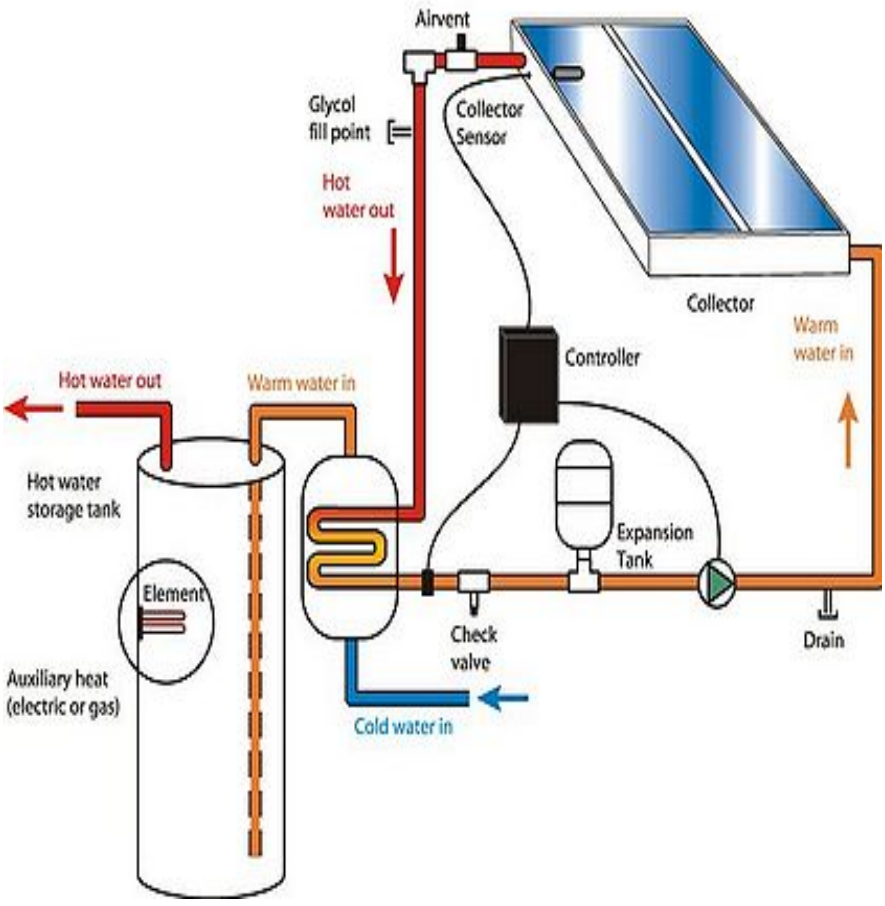
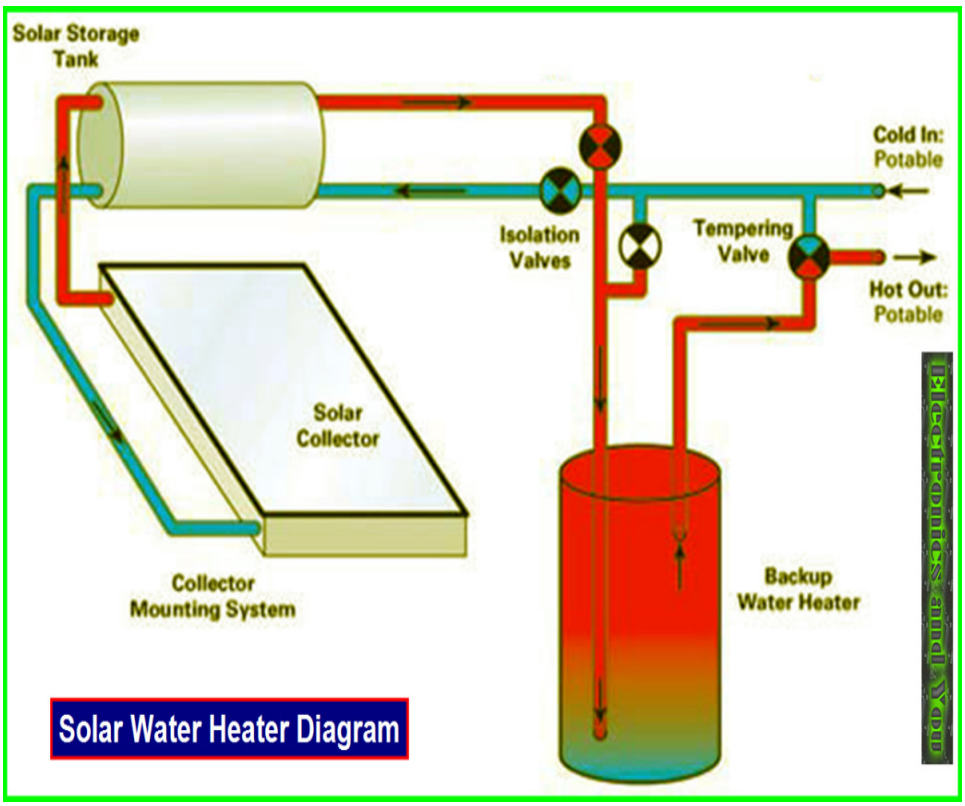


Fig. Solar heat collectors

Solar Water heaters



5.2 Wind energy

Moving air is called wind. Energy recovered from the force of the wind is called wind energy. The energy possessed by wind is because of its high speed. The wind energy is harnessed by making use of wind mills.

The wind power potential of India is about 45,000 MW out of which capacity of 8748 MW has been installed in India till 2008. India is one of the leading countries in generating the power through wind energy.

Gujarat, AP, Karnataka, MP and Rajasthan are states having more than 5000 MW potential each. These potentials could be improved if the technology of putting turbines in sea is embraced. There are wind farms on sea generating as high as 160 MW of power.

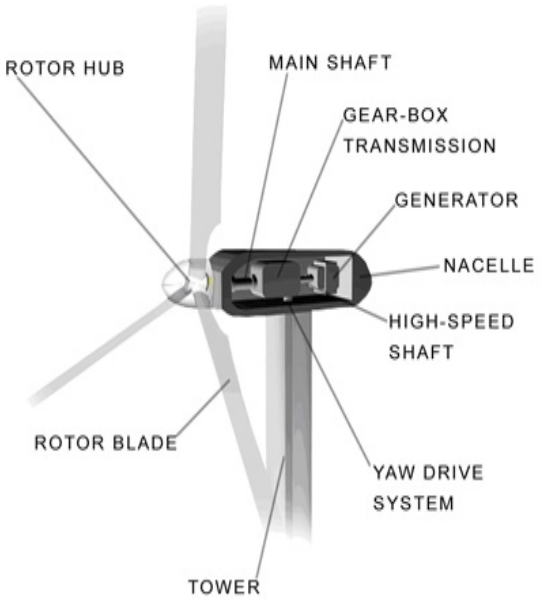
Harvesting of Wind energy.

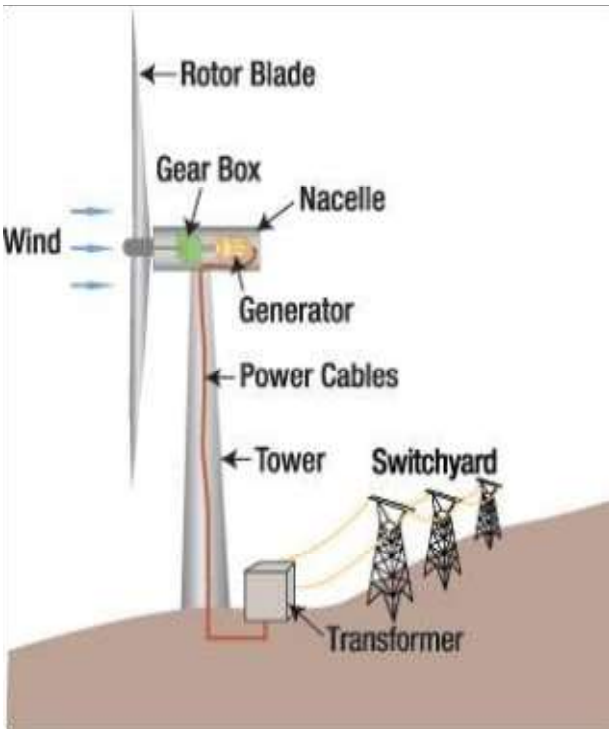
1. Wind Mills

The strike of blowing wind on the blades of the wind mill makes it rotating continuously. The rotational motion of the blade drives a number of machines like water pump, flour mills and electric generators.

2. Wind farms

When a large number of wind mills are installed and joined together in a definite pattern it forms a wind farm. The wind farms produce a large amount of electricity. The minimum speed required for satisfactory working of a wind generator is 15 km/hr.It does not cause any air pollution. It is very cheap.





5.3 Geothermal energy

Geothermal energy is thermal energy generated and stored in the Earth. Thermal energy is the energy that determines the temperature of matter. Earth's geothermal energy originates from the original formation of the planet (20%) and from radioactive decay of minerals (80%). Geothermal power is cost effective, reliable, sustainable, and environmentally friendly, but has historically been limited to areas near tectonic plate boundaries. Recent technological advances have dramatically expanded the range

and size of viable resources, especially for applications such as home heating, opening a potential for widespread exploitation. Geothermal wells release greenhouse gases trapped deep within the earth, but these emissions are much lower per energy unit than those of fossil fuels. As a result, geothermal power has the potential to help mitigate global warming if widely deployed in place of fossil fuels. Temperature of the earth increases at a rate of 20-750C per km, when we move down the earth surface.

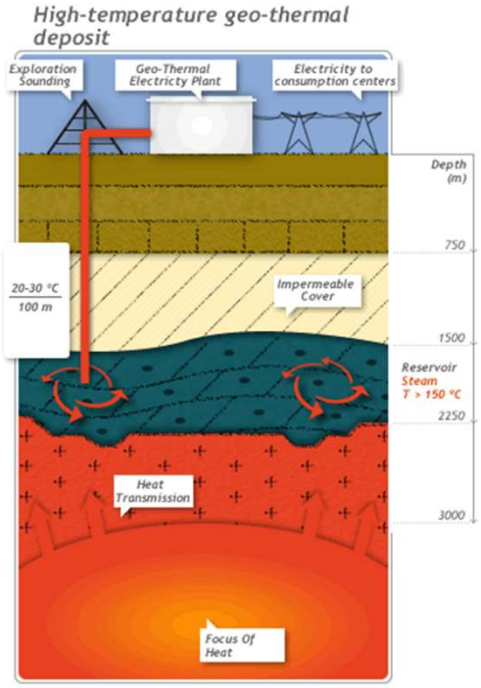
High temperature and high pressure steam fieldsexists below the earth's surface in many places. The energy harnessed from the high temperature present inside the earth is called geothermal energy.

Natural geysers

In some places, the hot water (or) steam comes out of the ground through cracks naturally in the form

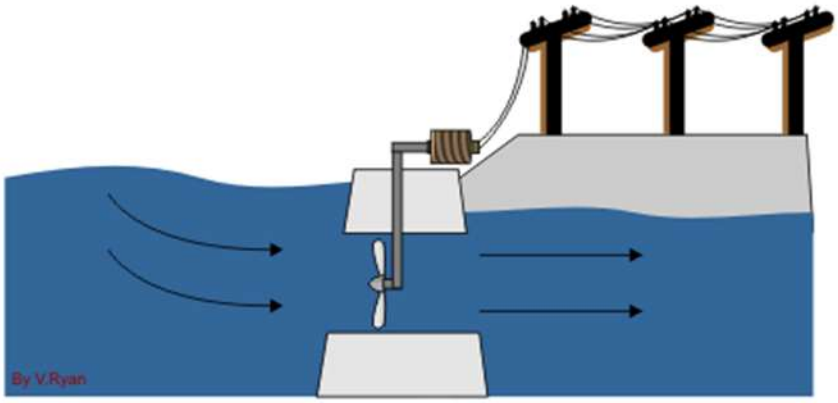
Artificial geysers

In some places, we can artificially drill a hole up to the hot region and by sending a pipe in it, we can make the hot water or steam to rush out through the pipe with very high pressure. Thus, the hot water (or) steam coming out from the natural (or) artificial geysers is allowed to rotate the turbine of a generator to produce electricity.



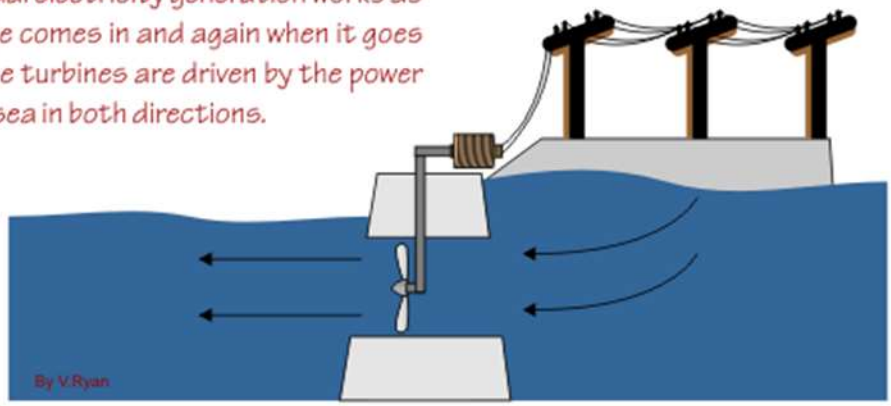
5.4. Tidal energy

Ocean tides, produced by gravitational forces of sun and moon, contain enormous amount of energy. The “high tide” and “low tide” refer to the rise and fall of water in the oceans.The tidal energy can be harnessed by constructing a tidal barrage.During high tide, the sea-water is allowed to flow into the reservoir of the barrage and rotates the turbine, which intern produces electricity by rotating the generators.During low tide, when the sea level is low, the sea water stored in the barrage reservoir is allowed to flow into the sea and again rotates the turbine.



TIDE COMING IN

This tidal electricity generation works as the tide comes in and again when it goes out. The turbines are driven by the power of the sea in both directions.



TIDE GOING OUT

5.4 Ocean thermal energy conversion (OTEC)

Ocean Thermal Energy Conversion (OTEC) uses the difference between cooler deep and warmer shallow or surface ocean waters to run a heat engine and produce useful work, usually in the form of electricity.

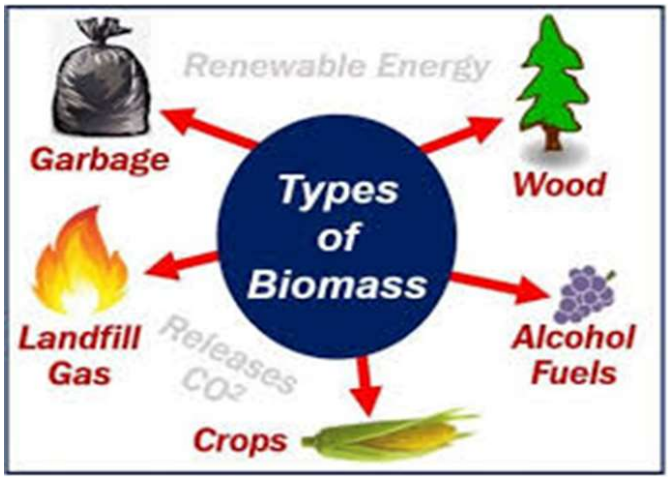
A heat engine gives greater efficiency and power when run with a large temperature difference. In the oceans the temperature difference between surface and deep water is greatest in the tropics, although still a modest 20 to 25 °C. It is therefore in the tropics that OTEC offers the greatest possibilities. OTEC has the potential to offer global amounts of energy that are 10 to 100 times greater than other ocean energy options such as wave power

5.5 Biomass energy

Biomass is the oldest means of energy used by humans along with solar energy. As soon as the fire was discovered, it was used widely among humans mainly for heat and light. Fire was generated using wood or leaves, which is basically a biomass. The biomass could be used to generate steam or power or used as a fuel. Power is generated using rice husk in Andhra Pradesh, while several bagasse based plants are there. India has a potential of 3500 MW from bagasse. Other fast growing plants could be planned over a huge area, so that it provides biomass for generating power.

Types of Bioenergy

(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 crop plants like sugarcane, sweet sorghum and sugarbeet, and carbohydrate rich potato, cereal etc. are some of the important energy plantations.



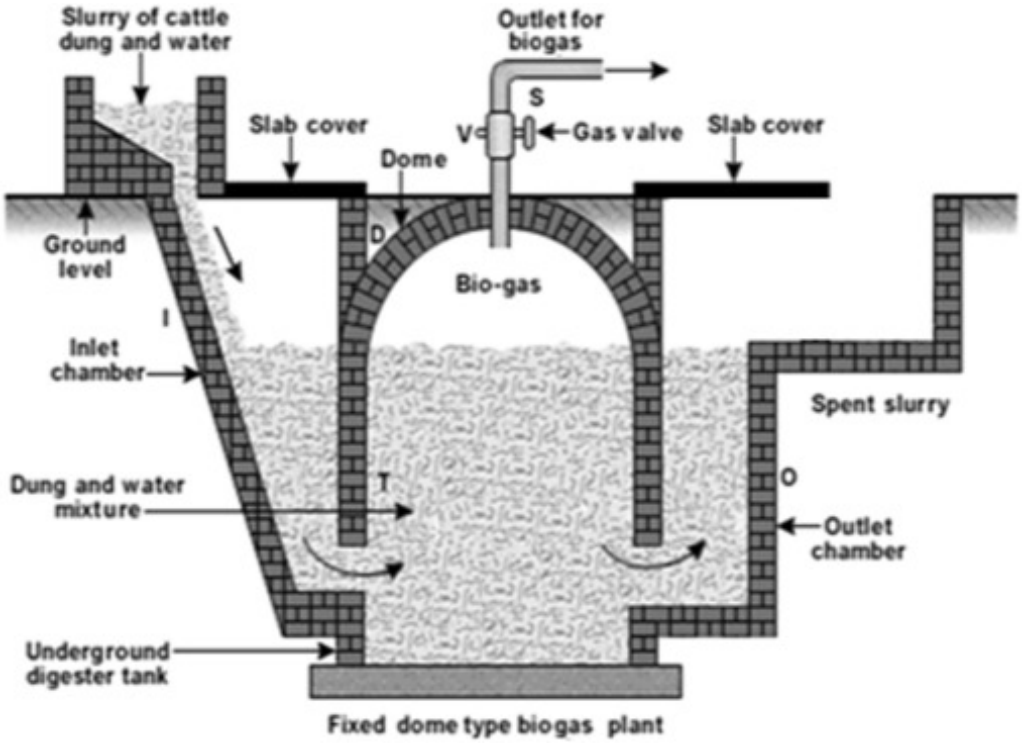
(b) Petro-crops: Certain latex-containing plants like Euphorbias and oil palms are rich in hydrocarbons and can yield an oil like substance under high temperature and pressure. This oily material may be

burned in diesel engines directly or may be refined 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. 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 burnt to produce heat.They may produce energy either by burning directly or converted into fuels by fermentation.

Biogas

Organic waste such as dead plant and animal material, animal dung, and kitchen waste can be converted by the anaerobic digestion or fermentation into a gaseous fuel called biogas. Biogas is a mixture of 65% methane (CH_4) and of 35% CO_2 and may have small amounts of hydrogen sulphide (H_2S), moisture and siloxanes. It is a renewable energy resulting from biomass. Biogas can be used as a fuel in any country for any heating purpose, such as cooking. It can also be used in anaerobic digesters where it is typically used in a gas engine to convert the energy in the gas into electricity and heat. Biogas can be compressed, much like natural gas, and used to power motor vehicles.



Fixed dome type biogas plant

Bio-fuels

Bio-fuels are the fuels, obtained by the **fermentation** of biomass.

Eg: Ethanol, Methanol

(a) Ethanol

Ethanol can be easily produced from the **sugarcane**. Its calorific value is less when compared to petrol, and produces much less heat than petrol.

(b) Methanol

Methanol can be easily obtained from **ethanol or sugar**-containing plants.

Its calorific value is also too low when compared to gasoline and diesel.

(c) Gasohol

Gasohol is a mixture of **ethanol + gasoline**.

In India trial is being carried out to use Gasohol in cars and buses.

- ✓ Gasohol is common fuel in Brazil and Zimbabwe for running cars and buses.
- ✓ Methanol is very useful since it burns at a lower temperature than gasoline or diesel. Due to its high calorific value, hydrogen can serve as an excellent fuel.
- ✓ Moreover it is non-polluting and can be easily produced.
- ✓ Presently H_2 is used in the form of liquid hydrogen as a fuel in spaceships.

India has more than 50 million hectare of wasteland, which could be utilized for cultivating fuel plants. Jatropha is one of the options which can be planted on arid lands and be used for production of bio fuels.

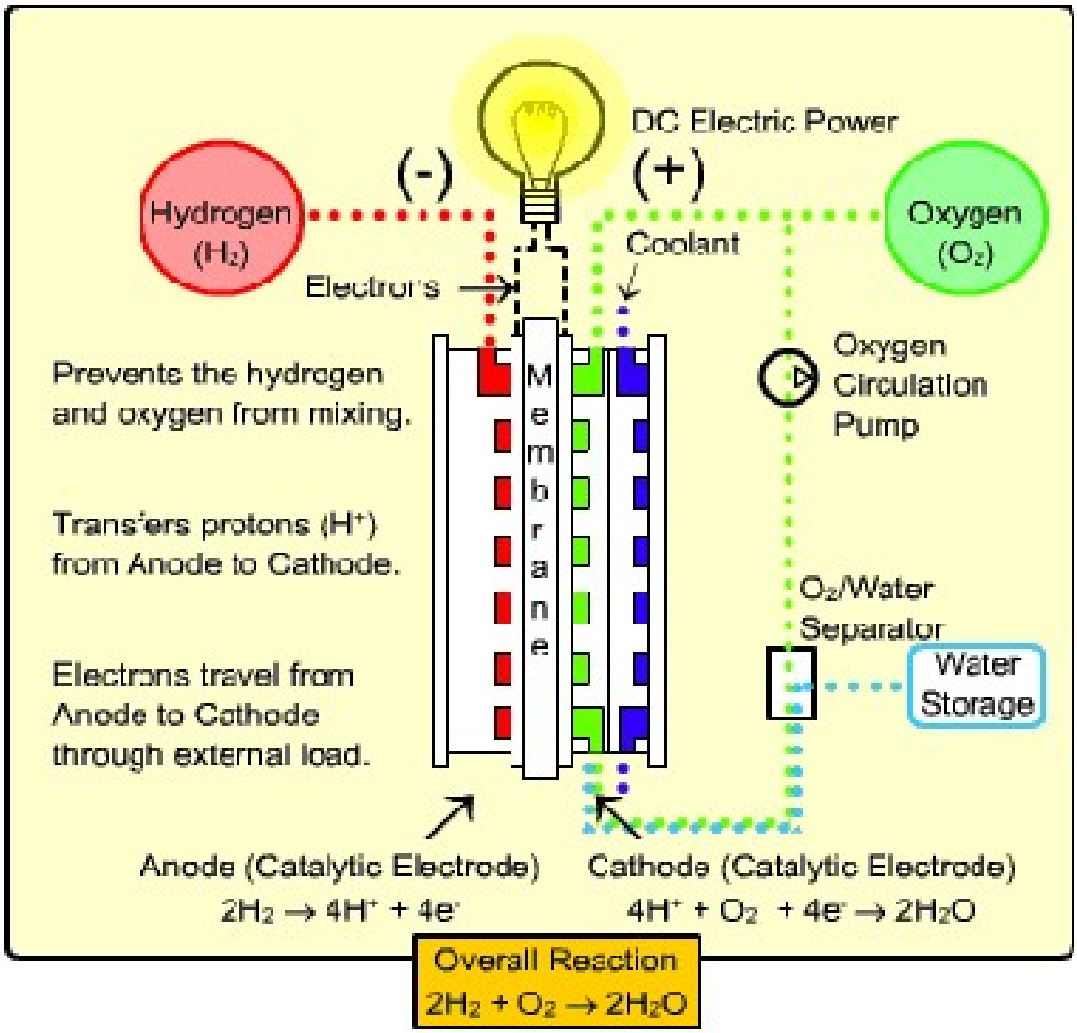
5.6. Hydrogen Energy:

- ▶ Hydrogen can be produced by **thermal dissociation** or **photolysis** or **electrolysis** of water.
- ▶ It possesses high calorific value.

- It is non polluting, because the combustion product is water.
- $2H_2+O_2$---->$2H_2O$+150KJ

Disadvantages of hydrogen fuel

- Hydrogen is highly inflammable and explosive in nature
- Safe handling is required
- It is difficult to store and transport.Highest calorific value, hydrogen can serve as an excellent fuel. Moreover, it is non-polluting



6. Problems Relate To the Use of Energy Resources

6.1 Fossil fuel

- Global warming
- Acid rains
- Dangers posed by leaded fuels ,Oil spills
- Water pollution caused by poorly managed coal mines
- Air pollution.

6.2 Alternate energy resources

- The initial cost of establishment of alternate energy generation is costlier than conventional resources.
- Maintenance of these structures is difficult.
- It requires more space.
- Energy supply is unpredictable during natural calamities.

7. Case Study

Importance of the energy resources in present economy and as a base for our future can be underlined by the fact that recent confrontations between some powerful nations of the world have primarily been attributed driven by objective to secure their energy supplies. Examples of this have been the two gulf wars. It was the hunger for energy resources that drove Iraq to lead an offensive over Kuwait and also reason for second Gulf war has been attributed to energy security by defence experts. In recent times, world has witnessed a confrontation at South China Sea between India, Vietnam and China over the issue of exploring natural gas and petroleum under the sea bed.

ECOSYSTEMS AND ECOLOGICAL SUCCESSION

No organism can exist by itself without the environment. The living organisms (biotic) and their non living (abiotic) environment are inseparable inter-related and interact upon each other. Any unit, in which there is interaction between organisms and their physicochemical environment and when there is an exchange of material between the two, is called ecosystem. The term *'Ecology'* has been derived from the Greek word Oikos, meaning house and Logos, means to study. The interaction results in continuous production, consumption and exchange of materials between the living and nonliving component of the environment following cyclic process.

1.1 TYPES OF ECOSYSTEM:

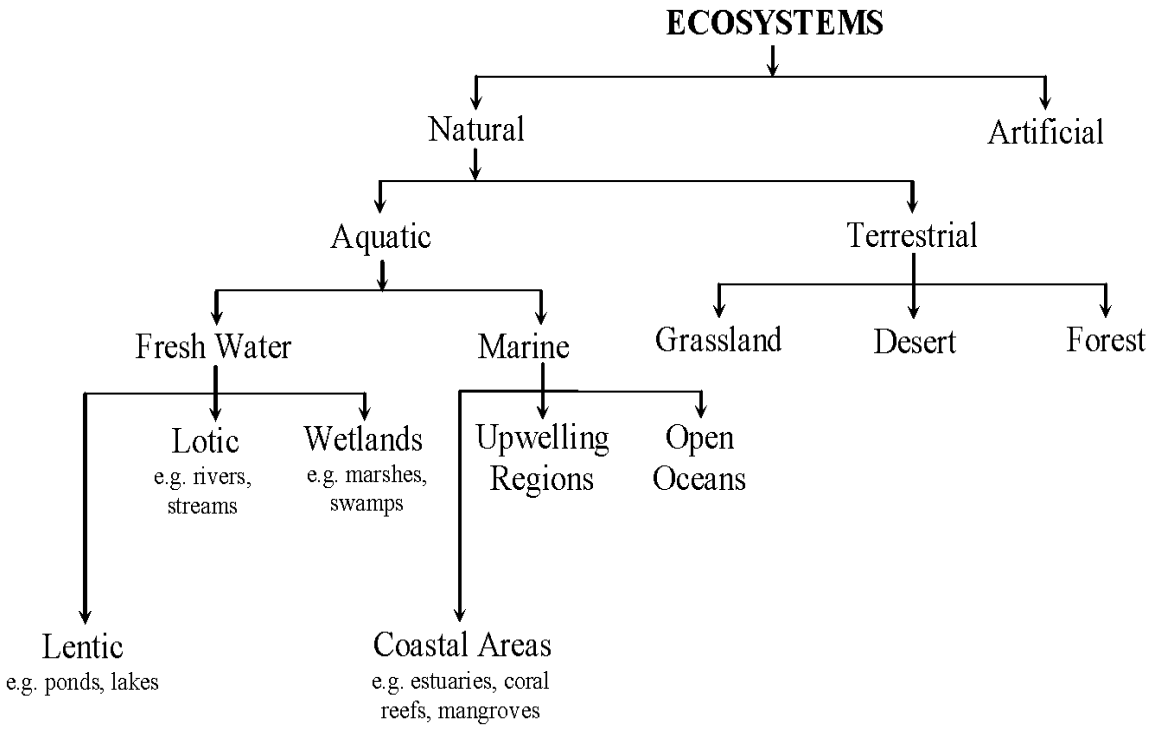
According to habitat types and formation, ecosystem are of following types:

1. Natural : Form by nature
2. Manmade: Form by Man

Natural ecosystem are of two types:

A: Terrestrial ecosystem: The ecosystem are operating in land.

B: Aquatic ecosystem: ecosystem operating in water.



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1.2 STRUCTURE OF ECOSYSTEM:

Ecosystem consist of two major components:

(A) **Abiotic components** (weather, earth, sun, water, soil, climate, atmosphere etc.)

(B) **Biotic components** (producer, consumer, decomposer)

(A) Abiotic structure (The non living environment)

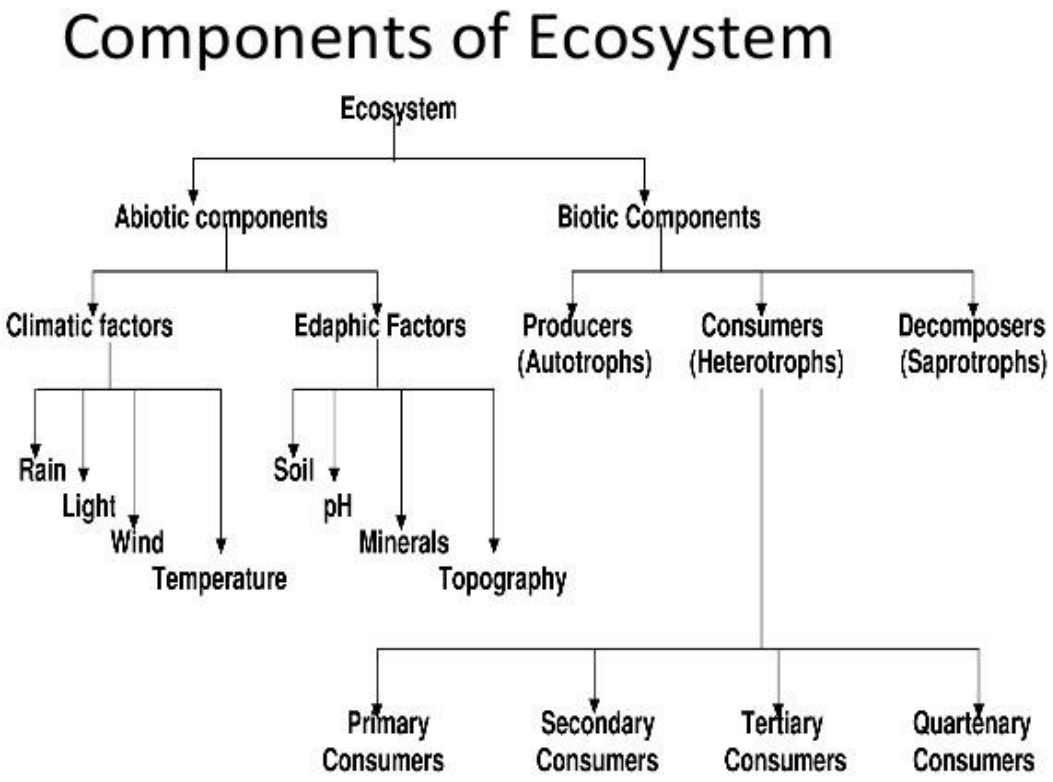
Components those are nonliving are called as abiotic components. The physical environment with its several interacting variables constitutes the abiotic components of an ecosystem. They have a strong influence on the structure, distribution, behavior and interrelationship of organisms. The non living substances enter into the body of living organisms, take a part of metabolic activities and then return to the environment. The abiotic factors include:

(i) The solid mineral matter of the earth i.e. lithosphere

(ii) The water in the ocean, river, lake, ponds etc. i.e. hydrosphere

(iii) The gaseous mixture in the air i.e. the atmosphere

(iv) The radiant solar energy i.e. radiant energy of sun



(B) Biotic structure (The living environment)

In an ecosystem, living organisms (plants and animals) are generally considered as the biotic components. The group of living organisms which can prepare their own food materials are called as autotrophic (auto means self, troph means nourishing) organisms. Examples of this category are all the green trees, grasses, crops, phytoplankton etc. In the other hand group of living organisms which can't prepare their own food materials and depends upon other living organism directly or indirectly are called as heterotrophic (hetero means other, troph means feeder) organisms. Examples of this category are all animals including human being. On the basis of their role and behavior in the ecosystem the biotic components are classified into three major groups like;

(i) Producers (ii) Consumers (iii) Decomposers.

(i) Producers

Producers are the autotrophic members of the ecosystem which are mainly green plants and are capable of synthesizing food from non-living simple inorganic substances. They include plants, algae and diatoms. They convert solar energy into chemical energy with the help of inorganic substances such as water and carbon dioxide and organic substances such as enzymes.

The kinetic energy of light is absorber by chlorophyll (the green pigment) in the cells of the plant. This removes the hydrogen atoms from water (H_2O) molecule. The hydrogen atoms combine with carbon atoms available from carbon dioxide (CO_2) to form a glucose molecule. As a result, the oxygen atoms that remain combine with each other to form oxygen gas which is released in to the air. This physiological process taking place in plant is called photosynthesis. The overall process of photosynthesis is described in the equation below;

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

The rate of photosynthesis is proportional to the intensity of light. Utmost, 2 calories of sugar are formed for each 100 calories of light energy falling on the plant. Thus green plants are considered as machines in performing the conversion of light energy to chemical energy which is the source of energy for other living organisms of ecosystem.

(ii) Consumers

Consumers are heterotrophic members of the ecosystem, which feed upon other living organisms. The animals lack chlorophyll and are unable to synthesize their own food. Therefore, they depend upon the producer for their food. On the basis of their food habits, consumers are of two types, i.e. herbivores (plant eaters) and carnivorous (flesh eaters). Insects, zooplankton, deer, cow goat, elephant etc. are the example of herbivores and tiger, lion etc. are the examples of carnivorous. Further, on the basis of their food habits carnivores are either order I (C 1), order II (C 2) and so on.

Classes of Consumers

Primary consumers (also called as secondary producer)- herbivorous (plant eaters) e.g. rabbit, dear, goat, cattle, grasshopper etc.

Secondary consumers (also called as tertiary producer) -primary carnivorous (flash eaters) e. g. cat, dog, fox, snake etc.

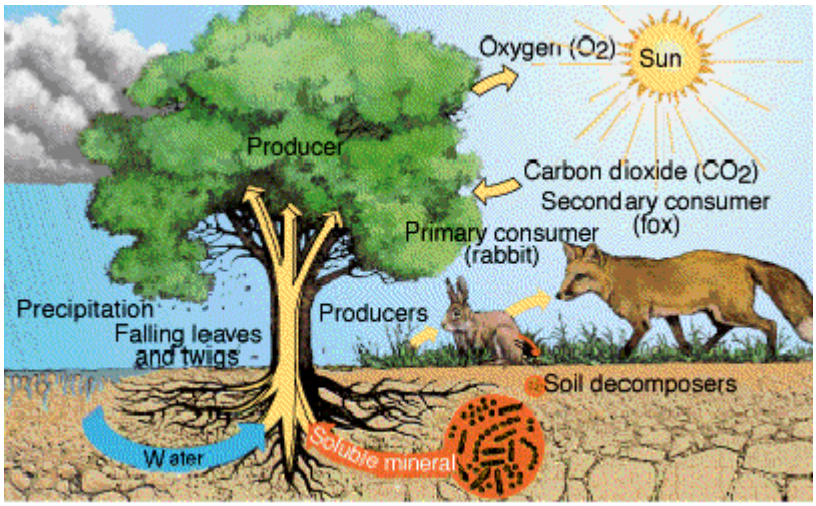
Tertiary consumers – (also called secondary carnivorous)- top carnivorous (meat eaters) e.g. wolves.

Quaternary consumer – Omnivores (eat both plants/animals) e.g. man

About 60-90% of the food eaten by consumers is oxidized for energy and the remaining 10-40% is converted to the body tissue of the consumer. This is the fraction that enables the body to grow, maintain and repair by itself.

(iii)Decomposers

Decomposers are also heterotrophic organisms which depend upon dead organic matter for their food. Mostly bacteria, actinomycetes and fungi are microorganisms coming under this group. They imbibe dead organic matter and break down the complex organic matter like cellulose, hemicelluloses, chitin etc. which are present in the plant and animal body and converts it into simpler substances which can be used by the green plants.



Role of organisms

1.3 FUNCTION OF ECOSYSTEM:

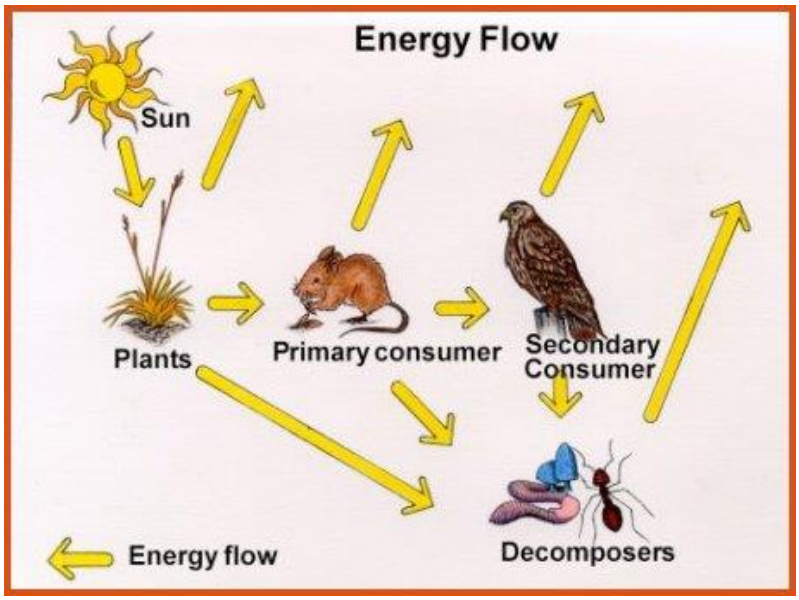
Some of the important functions of any ecosystem are;

- Energy flow
- Food chain
- Food web
- Nutrient cycles
- Ecological pyramid

Energy Flow In Ecosystem:

- ❖ All organisms must obtain a supply of energy and nutrients from their environment in order to survive.
- ❖ The transformations of energy in an ecosystem begin first with the input of energy from the sun.
- ❖ Because, it is the first step in the production of energy for living things, it is called “Primary production”.
- ❖ Photosynthesis -- Chemical reaction where green plants use water & carbon dioxide to store the sun’s energy in glucose.
- ❖ ENERGY is stored in glucose.
- ❖ Glucose is stored as starch in plants
- ❖ The majority of autotrophs are photoautotrophs that harness the energy of the sun and pass some of this energy onto consumers through feeding pathways.
- ❖ The energy contained within producers and consumers is ultimately passed to the decomposers that are responsible for the constant recycling of nutrients.
- ❖ Thus, there is a one-way flow of energy through the biotic community and a cycling of nutrients between the biotic and abiotic components of the ecosystem

- Energy flow cannot occur in reverse direction.
- Starts from autotrophs (the producer level, i.e., first trophic level) to Heterotrophs including plant eaters or Herbivores (second trophic level) and so on.
- The amount of energy decreases with successive trophic levels.
- Only About 1% of energy from the sun is used by green plants & rest remains unutilized.
- Similarly, there is loss of energy in each trophic level.
- The transfer of food energy between the organisms in an ecosystem can be tracked by constructing food chains, food webs, pyramids of numbers, biomass and energy and energy flow diagrams.



Energy Flow

Food Chain:

All living things need food to get energy to grow, move and reproduce. But what do these living things feed on? Small insects feed on green plants and bigger animals feed on smaller ones and so on. This feeding relationship in an ecosystem is called as a food chain. Food chain is usually in a sequence, with an arrow used to show the flow of energy.

- A food chain may be defined as, “the transfer of energy and nutrients through a series of organisms with repeated process of eating and being eaten”.
- In an ecosystem, all the organisms are linked together with one another by food relationship.
- Each organism living or dead is potential food for some other organism.

There are three types of food chain exists in a mature ecosystem;

- Grazing food chain

- Detritus food chain
- Parasitic food chain
- **Grazing food** chain starts from green plants followed by grazing herbivorous and finally become a prey to carnivorous. Here the food chains are directly depending on an influx of solar radiation. This depends on the capture of solar energy by the autotrophic organisms and conversion of this to chemical energy and the movement of this energy in form of food to herbivorous and then to carnivorous of different orders. Ecosystems like grassland, pond or lake are herbivorous based and herbivorous are considered as important consumers. In Grazing food chain, the primary producers are the living green plants which are grazed on by grazing animals. It is found in aquatic and grassland ecosystem.
- Food chain in aquatic ecosystem:- Phytoplankton →Zooplankton→ Small Fish→ Big Fish
- Food chain in grassland ecosystem:- Grass → Rabbit → Fox → Wolf →Tiger

  or

  Grass→ Grasshopper→ Frog→ Snake → Hawk

❖

- **Detritus food chain** starts from dead organic matter into microorganisms and then to the organisms feeding on detritus and their predators. Here the food chain does not depend on the capture of solar energy but it depends on the influx of dead organic matter. In case of forest ecosystem, big plants are mainly the primary producers and the dominant primary consumers are insects. The dominant detritus feeding animals in such ecosystem are microarthropods, oligochaetes and microorganisms such as bacteria, fungi, actinomycetes, protozoa etc. The dead complex organic matter is broken down into simple nutrients by microorganisms like fungi and bacteria. This type of food chain is found in forest ecosystem.
  - Example of detritus food chain:- Dead organic matter→ Detritus → Predators

- In **Parasitic food chain** either the producer or the consumer is parasitized and therefore the food passes to the smaller organism. Parasites live on or inside the body of the host and

derive benefit from the host. The parasite gets nutritional benefit and the host is harmed. The energy transfer through this kind of food chain is not significant.

- Examples of parasitic food chain:-
- Producer→ Herbivores (Host)→ Parasite (tick / aphid)→ Birds →Carnivore
  - or
- Trees→ Fruit eating birds→ Lice and bugs→ Bacteria and fungi
  - or
- Radiant energy of the sun -> Green Plants -> Sheep -> Liver fluke
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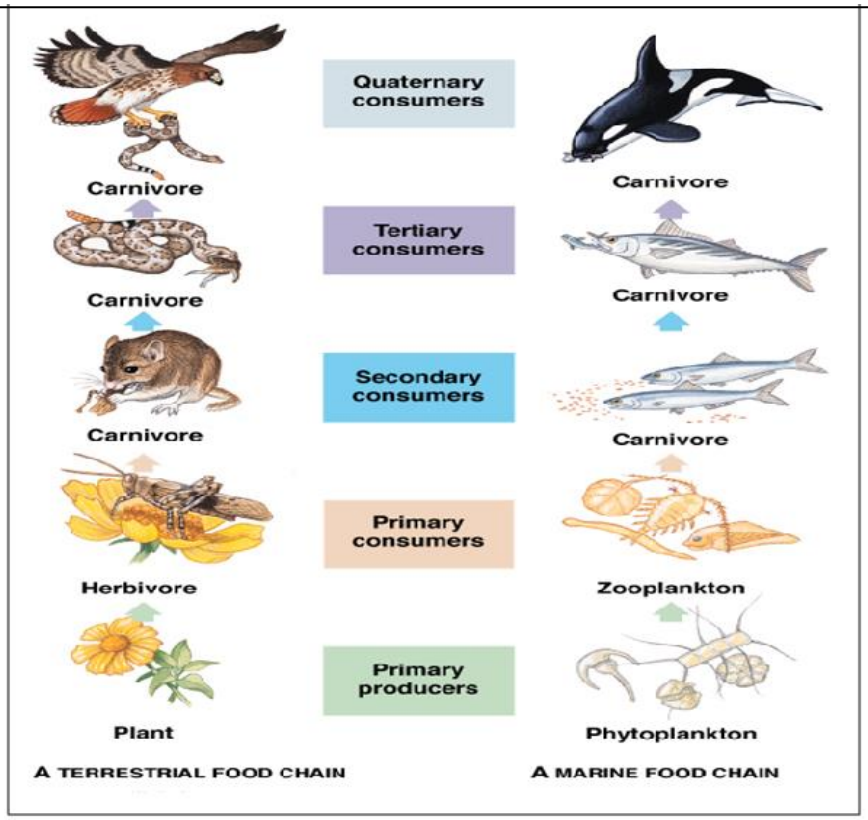
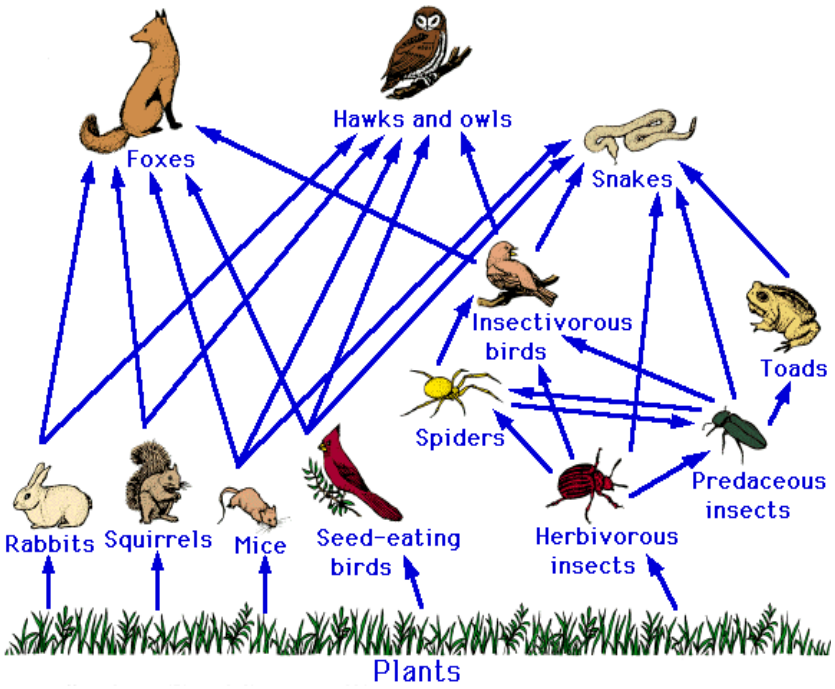


Food Chain

Food Web:

- Under natural conditions, the linear arrangement of food chains hardly occurs & these remains connected interconnected with each other through different types of organisms.
- Interlocking pattern of several interlinked food chains is termed as food web.



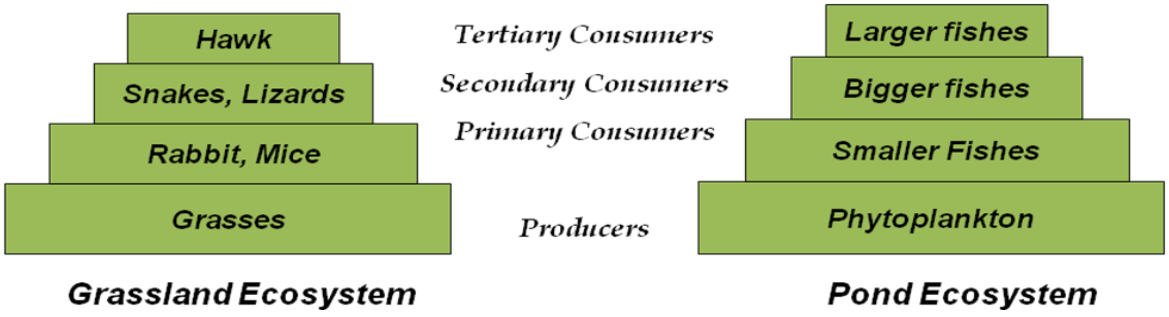
Food web in grassland ecosystem

Ecological Pyramids:

- An"Ecological pyramid" is a graphical representation that shows the relative amounts of energy or matter contained within each tropic level in a food chain or food web.
- An ecological pyramid shows the relationship between consumers and producers at different tropic levels in an ecosystem
- There are three ecological pyramids recognized by ecologists:

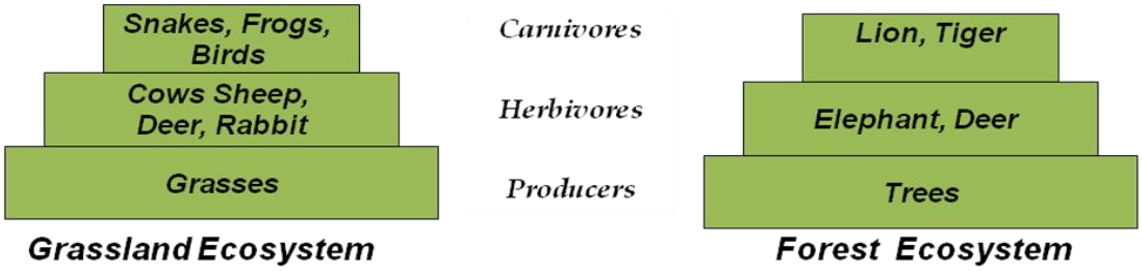
1. Pyramid of Numbers:

- ✓ Shows the relative number of individual organisms at each tropic level.



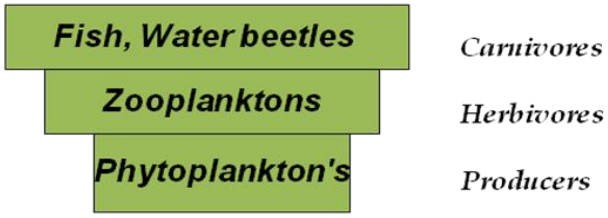
2.Pyramid of Biomass

- A pyramid of biomass represents the total dry mass (in grams per square meter of area) of all the organisms in each tropic level at a particular time.



Grassland Ecosystem

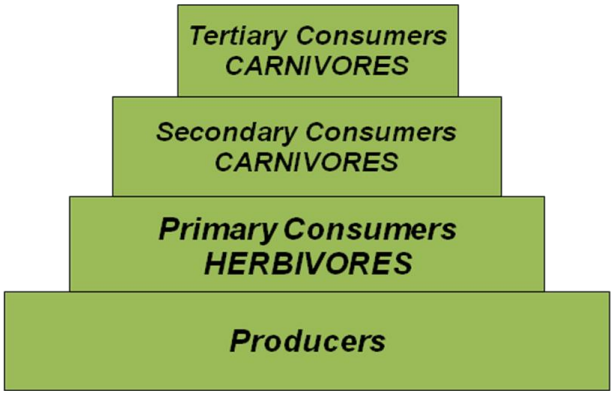
Forest Ecosystem



Pond Ecosystem

3. Pyramid of Energy

- A pyramid of biomass represents the rate of energy flow and/or productivity at successive tropic levels. The pyramids of energy are always upright.



Nutrient Cycles:

- Nutrient cycles involve storage and transfer of nutrients through different components of the ecosystem, so that the nutrients are repeadly used.
- The cyclic movements of chemical elements of the biosphere between the organisms and environment are referred as **"Biogeochemical Cycles"**

Gaseous cycle: Those elements in which the reservoir is the air or the oceans (via evaporation). Gaseous cycles include those of Carbon, Nitrogen, Oxygen, Carbon, and Water.

Sedimentary cycle: Those elements which are received from the Earth's crust. Sedimentary cycles include those of iron, calcium, phosphorus, and other more earth bound elements.

1. Nitrogen Cycle

- Nitrogen is crucial for all organisms
  - Nucleic acids
  - Proteins
  - Chlorophyll
- Nitrogen- 78% in Atmosphere
- N_2 is very stable and must be broken apart by organisms, combined with other atoms into a usable form.
- Nitrogen cycle completes in 5 steps:

i) Nitrogen Fixation

Conversion of $N_2 \rightarrow NH_3$

- Combustion, volcanic action, Lightning, Industrial processes (making fertilizer). Bacteria (Azotobactor, Clostridium, Nostoc etc.)

ii) Nitrification

Conversion of $NH_3 \rightarrow NO_3$

Soil bacteria convert in a two step process.

iii) Assimilation

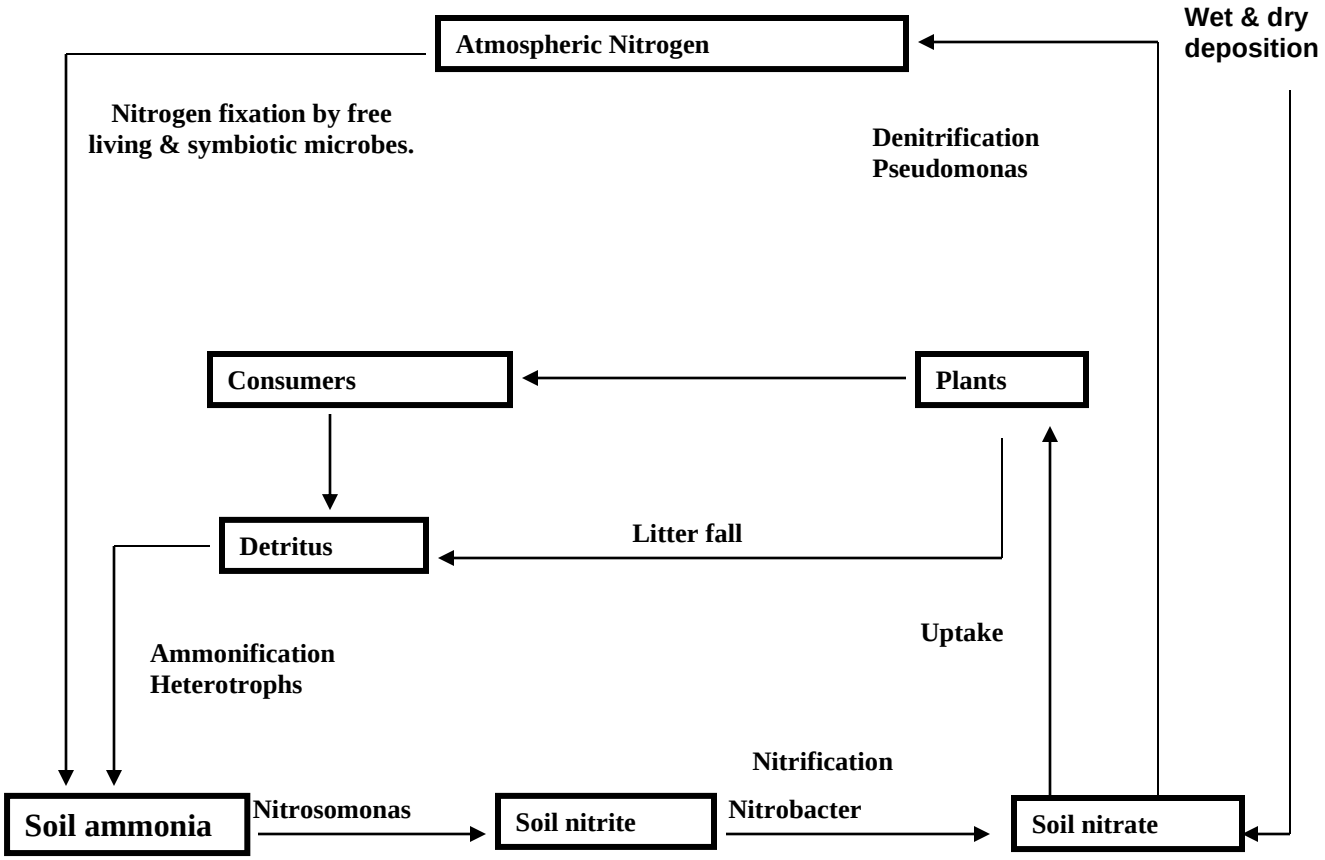
Roots absorb NH_3, NH_4, or NO_3 and incorporate them into nucleic acids and protein.

iv) Ammonification

Amino acids and nucleotides are broken down into waste products NH_3 or NH_4

v) Denitrification

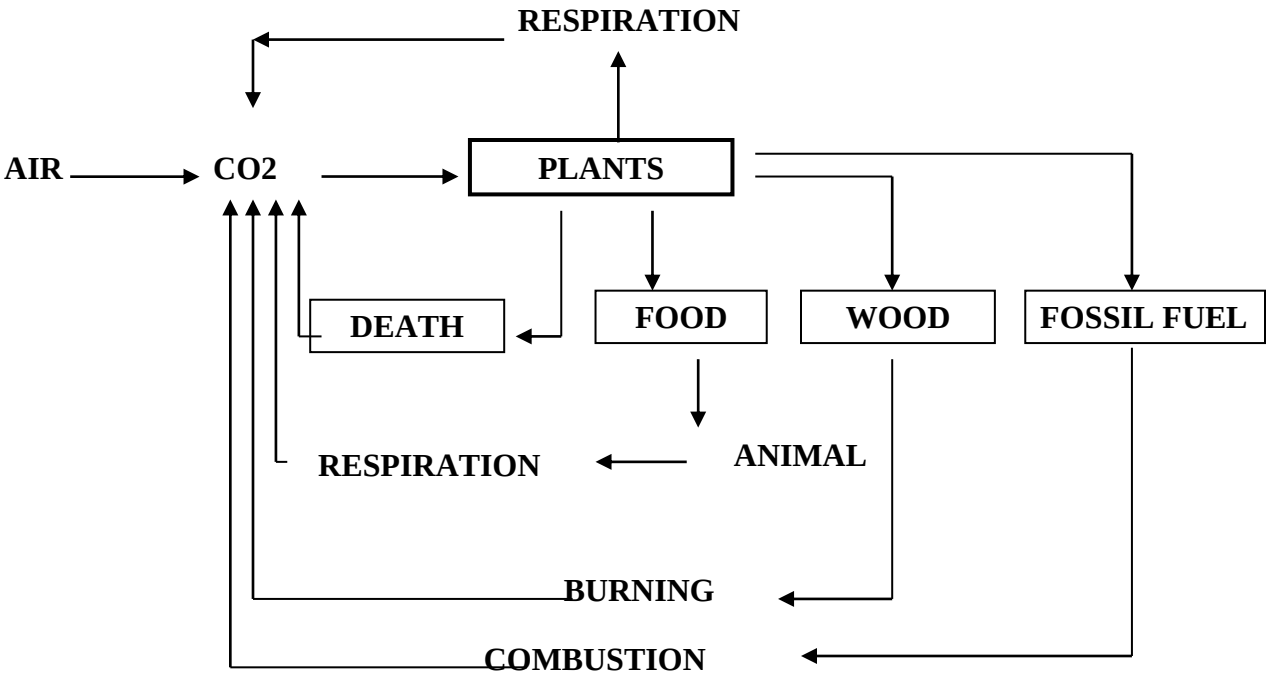
The reduction of NO_3 to N_2 .Denitrifying bacteria return some of the nitrogen to the atmosphere.



1.Nitrogen Cycle

2. Carbon Cycle

- Carbon enters plants, etc., as CO_2
  - Bacteria process carbon in a fashion that allows it to be recycled.
  - Obtain energy from the molecules, and convert carbohydrates to carbon dioxide as a result of respiration.
- Photosynthesis removes carbon from the abiotic environment (fixes carbon into organic molecules)
- Carbon moves through food chain through consumption of one organisms by another
- Cellular respiration, combustion, and erosion of limestone return carbon to the atmosphere, water and abiotic environment.

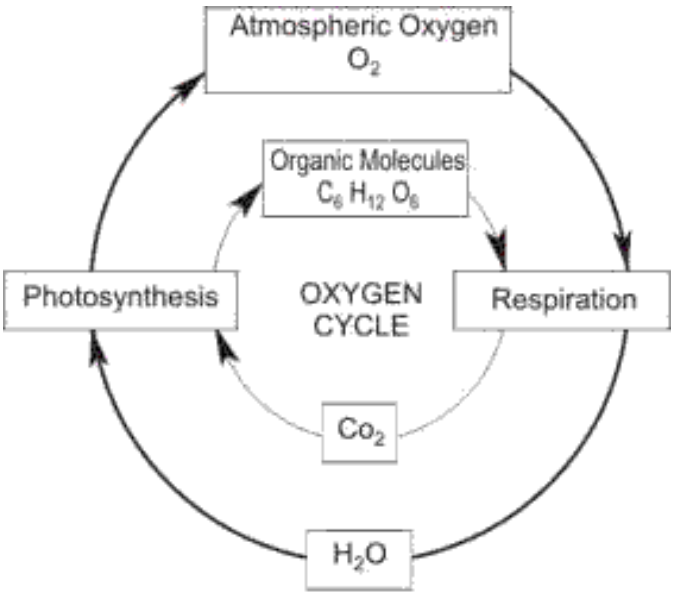


2. Carbon Cycle

The source of atmospheric carbon dioxide is variable but only plants can utilize atmospheric carbon directly

3.Oxygen Cycle

Oxygen is an important element of life on earth. It is the most common element of human body which makes up about 65% of the mass of the human body, most of which is in the form of water (H_2O). Oxygen also makes up about 30% of the Earth and 20% of the atmosphere. Oxygen is present at about 20.94% by volume in the atmosphere and in dissolved state in water. It also present in combined state with CO_2, CO_3^{2-}, HCO_3^-. The oxygen cycle describes the movement of oxygen within its three main reservoirs i. e. the atmosphere (air), the total content of biological matter within the biosphere (the living part of the earth), and the lithosphere (earth's crust). Plants, animals and human beings use oxygen from the surrounding for aerobic respiration and release oxygen in the form of CO_2 and water. Green plant use CO_2 during photosynthesis and release oxygen to atmosphere. The following table offer estimates of oxygen cycle reservoir capacities and fluxes.



Oxygen cycle

1.4 ECOLOGICAL SUCCESSION

- Ecological succession is defined as, "A change in the community in which new populations of organisms gradually replace existing ones".
- There are two types of ecological succession:

1) Primary Succession

- Occurs where there is no soil, e.g. after a volcanic eruption or a glacial retreat.
- "Pioneer organisms"
- Simple plants first – no or shallow roots.
- Gradual influx of more complicated and larger plants as the habitat changes
- Unfavorable for life at first.
- Ends with a "climax community" – ecosystem stays constant, provided there are no changes in abiotic influences.

2) Secondary Succession

- Community development in the areas that were previously occupied by other community.
- Occurs after a disturbance. E.g., loss of trees after disease, Fire or wind, deforestation etc.
- Conditions are favorable for as soil and nutrients are already present.
- More rapid than primary succession.
-

Primary Succession Vs Secondary Succession

Primary	Secondary
➢ No soil. ➢ Pioneer species. ➢ Weathering & decomposition ➢ Humus and sand increase over time. ➢ End = Climax community.	➢ Soil already exists. ➢ Seeds have suitable soil conditions. ➢ Occurs much faster. ➢ Climax community.

XEROSERE (Primary Succession)

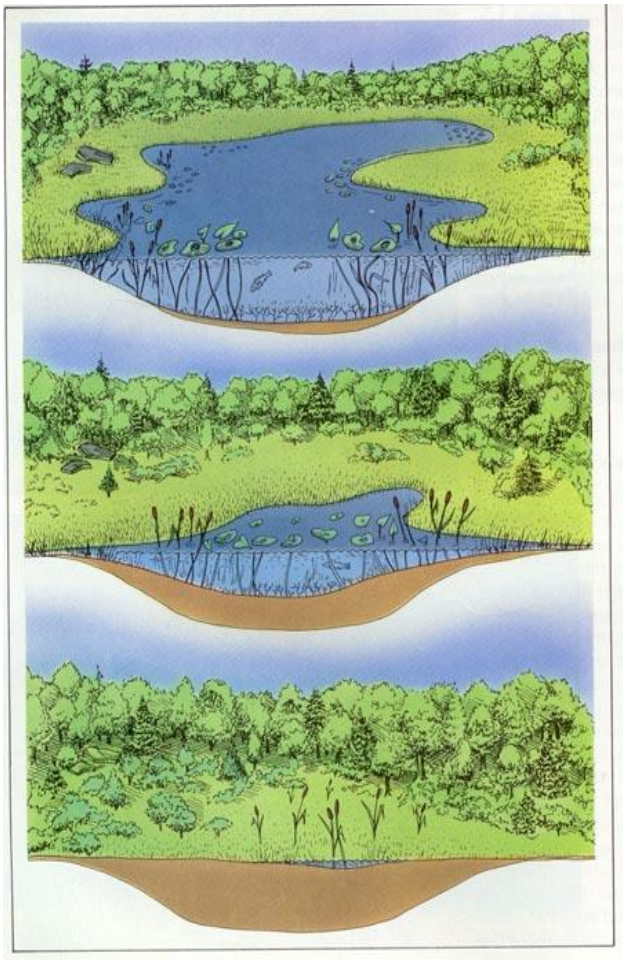
Xerosere is a plant succession which is limited by water availability. It includes the different stages in a xerarch succession. Xerarch succession of ecological communities originated in extremely dry situation such as sand deserts, sand dunes, salt deserts, rock deserts etc. A xerosere may include lithoseres (on rock) and psammoseres (on sand).

STAGES OF XEROSERE

- Bare rocks
- Crustose lichen stage
- Foliose and fruticose lichen stage
- Moss stage
- Herb stage
- Shrub stage
- Tree stage
- Climax stage

2) HYDROSERE (Secondary Succession)

- A Hydrosere is a plant succession which occurs in an area of fresh water, be it an oxbow lake, kettle lake etc. In time, an area of open freshwater will naturally dry out, ultimately becoming woodland. During this change, a range of different land types such as swamp and marsh will succeed each other.
- The succession from open water to climax woodland takes centuries or millennia. Some intermediate stages will last a shorter time than others. For example, swamp may change to marsh within a decade or less. How long it takes will depend largely on the amount of siltation occurring in the area of open water.



STAGES OF HYDROSERE

1. Phytoplankton stage
2. Submerged stage
3. Floating stage
4. Reed swamp stage
5. Sedge-meadow stage
6. Woodland stage
7. Climax stage

Summary of ecological succession

1. Ecological succession is the orderly and progressive replacement of one community by another until a relative stable community occupies the area.

2. It is of two types i.e. primary succession and secondary succession.
3. Species composition, change in species diversity, progressive increase in biomass, shift in community metabolism are some of the trends of ecological succession.
4. Pioneers are the beginners/starters of any ecological succession.
5. The process of succession starts from a pioneer and through some seral stages it ends in a climax stage which is a forest community.
6. Ability to survive on low nutrient, slow growth rate, small in size, dynamic in interacting with other species are some of the important characteristic feature of a pioneer.
7. When the succession stats from an aquatic environment it is called hydrosere and when it starts from a rock in desert condition it is known as xerosere.

FOREST ECOSYSTEM (TERRESTRIAL ECOSYSTEM)

1 Introduction

- A forest is an area with a high density of trees.
- World's total land area is 13,076 million hectares - (Source: FAO; 1989)
- Of which total forests account for about 31% of the world's land area.
- In India, the forest cover is roughly 19% of the total land area.
- The forest ecosystems are of great concern from the environmental point of view.
- It provides numerous environmental services like;
    - Nutrient cycling,
    - Maintaining biodiversity
    - Providing wildlife habitat
    - Affecting rainfall patterns
    - Regulating stream flow
    - Storing water
    - Reducing flooding
    - Preventing soil erosion
    - Reclaiming degraded land & many more….
- Apart from environmental values, forest ecosystems have some traditional values as well.
- Examples are:
    - Fire Wood & Timber.
    - Fruits.

- Gums.
- Herbs & drugs.

1.1 Structure and Function of Forest Ecosystem

I. Biotic components

- The various biotic components, representatives from the three functional groups, of a forest ecosystem are:

1) Producer Organisms

- In a forest, the producers are mainly trees.
- Trees are of different kinds depending upon the type of forest developed in that climate.
- Apart from trees, climbers, epiphytes, shrubs and ground vegetation.
- Dominant species of trees in major types of forest ecosystems are:
  - Tectona grandis, Acer, Betula, Picea, Pine, Cedrus.

2) Consumers

- In a forest, consumers are of three main types;

a) Primary Consumers

- These are Herbivores which feed directly on producers.

  Eg:

  - Ants, Beetles, Bugs, spiders etc. feeding on tree leaves.
  - Larger animals such as Elephants, Deer, giraffe etc. grazing on shoots and/or fruits of trees.

b) Secondary Consumers

- These are carnivores and feed on primary consumers.

  Eg: Birds, Lizards, Frogs, Snakes and Foxes.

c) Tertiary Consumers

- These are secondary carnivores and feed on secondary consumers
  - These include top carnivores like Lion, Tiger.

3) Decomposers

- These include wide variety of saprotrophic micro- organism like;
  - Bacteria (Bacillus Sp., Clostridium sp., pseudomonas.
  - Fungi (Aspergillus sp., Ganoderma sp., Fusarium.
  - Actinomycetes (Streptomyces).
- They attract the dead or decayed bodies of organisms & thus decomposition takes place.
- Therefore, nutrients are released for reuse.

II. Abiotic components

- These include basic inorganic & organic compounds present in the soil & atmosphere.
- In addition dead organic debris is also found littered in forests.

Producers: Different tree species

Consumers in a Forest Ecosystem

Decomposers in a Forest ecosystem

Fig- Forest Ecosystem

GRASSLAND ECOSYSTEM (TERRESTRIAL ECOSYSTEM)

1. Introduction

- Grasslands (also called Greenswards) are areas where the vegetation is dominated by grasses and other herbaceous (non-woody) plants.
- Grasslands occupy about 24% of the earth's surface.
- Grasslands occur in regions too dry for forests and too moist for deserts
- The annual rainfall ranges between 25- 75 cm, Usually seasonal
- The principal grasslands include:
  - Prairies (Canada, USA),Pampas (South America),Steppes (Europe & Asia) Veldts (Africa)
- The highest abundance & greatest diversity of large mammals are found in these ecosystems.
- The dominant animal species include
  - Wild horses, asses & antelope of Eurasia,
  - Herds of Bison of America; and

- The antelope & other large herbivores of Africa.

1.1. Structure and functions of Grassland Ecosystems

I. Biotic components

1) Producer Organisms

- In grassland, producers are mainly grasses; though, a few herbs & shrubs also contribute to primary production of biomass.
- Some of the most common species of grasses are:
  - Brachiaria sp., Cynodon sp., Desmodium sp., Digitaria sp.

2) Consumers

- In a grassland, consumers are of three main types;

a) Primary Consumers

- The primary consumers are herbivores feeding directly on grasses. These are grazing animals such as
  - Cows, Buffaloes, Sheep, Goats, Deer, Rabbits etc.
  - Besides them, numerous species of insects, termites, etc are also present.

b) Secondary Consumers

- These are carnivores that feed on primary consumers (Herbivores)
- These include;-Frogs, Snakes, Lizards, Birds, Foxes, Jackals etc.

c) Tertiary Consumers

- These include hawks etc. which feed on secondary consumers.

3) Decomposers

- These include wide variety of saprotrophic micro- organism like: Bacteria; Fungi; Actinomycetes
- They attract the dead or decayed bodies of organisms & thus decomposition takes place.
- Therefore, nutrients are released for reuse by producers.

II. Abiotic components

- These include basic inorganic & organic compounds present in the soil & aerial environment.
- The essential elements like C, H, N, O, P, S etc. are supplied by water, nitrogen, nitrates, sulphates, phosphates present in soil & atmosphere.

Producers: Different grass species

Consumers of Grassland ecosystem

Decomposers in a Grassland ecosystem

Fig. Grassland Ecosystem

DESERT ECOSYSTEM

1. Introduction

- A desert is a landscape or region that receives almost no precipitation.
- Deserts are defined as areas with an average annual precipitation of less than 250 millimeters per year.
- It occupies about 17% of the earth's surface.
- Deserts are characterized by hot days & cold nights.
- The deserts of the world are mainly located in the

  South- western United States, Mexico, North

  America, Asia (Thar, Gobi, Tibet) & west Asia.
- Deserts are characterized by scanty flora & fauna.
- Soils of deserts often have abundant nutrients but little or no organic matter.

1.1. Sturucture and Functions of Desert Ecosystms

I. Biotic components

1) Producer Organisms

- In a desert, producers are mainly shrubs/bushes; some grasses & a few trees.
- Dominant plant species include: Succulents (water - retaining plants adapted to arid climate or soil conditions) & hardy grasses.
- Besides some lower plants such as lichens & xerophytic mosses are also present.

2) Consumer Organisms

These include animals such as insects, reptiles which are capable of living in xeric conditions

- Besides some nocturnal rodents, birds & some mammalians like camel etc are also found.

3) Decomposers

Due to poor vegetation with very low amount of dead organic matter, decomposers are poor in desert ecosystem.

- The common decomposers are some bacteria & fungi, most of which are thermophillic.

II. Abiotic components

Due to high temperature & very low rainfall, the organic substances are poorly present in the soil.

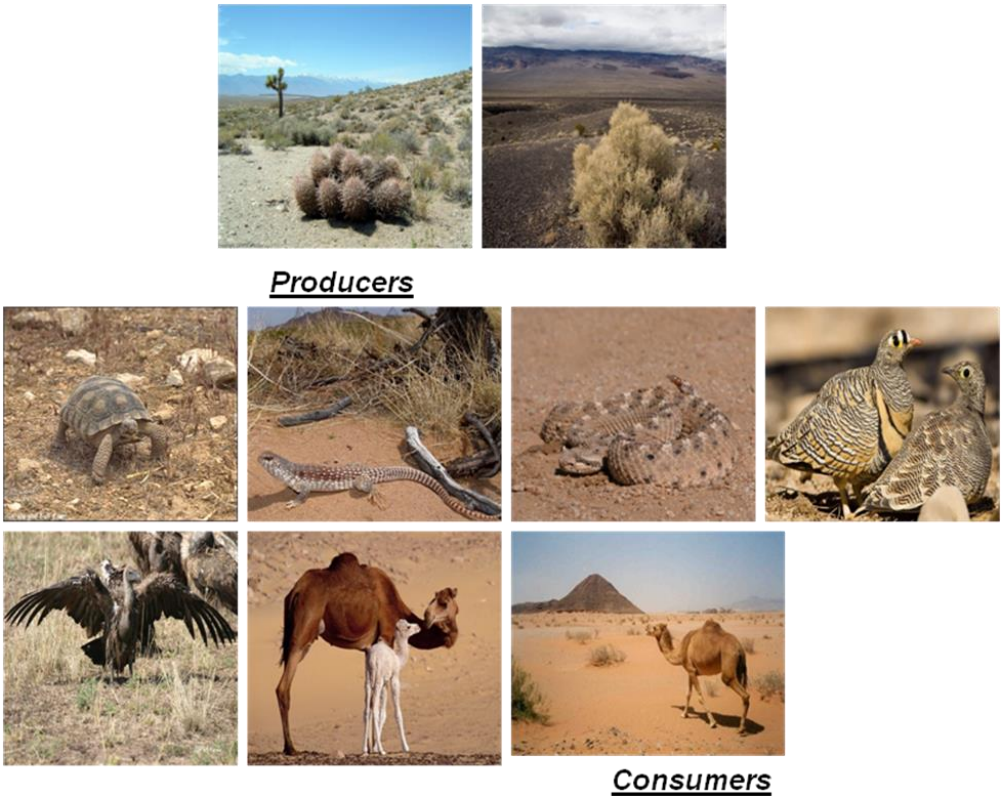


Fig. Desert Ecosystem

AQUATIC ECOSYSTEMS

1. Introduction

- Aquatic ecosystems deal with biotic community present in water bodies.
- In terrestrial ecosystem, carbon dioxide & oxygen are present in gaseous form whereas in aquatic ecosystem, these are available in dissolved state.
- Depending upon the quality and nature of water, the aquatic ecosystem are categorized into:

- Freshwater Ecosystem and
- Marine Ecosystem.

2. Freshwater Ecosystems

- Freshwater ecosystems cover 0.8% of the Earth's surface and contain 0.009% of its total water.
- Freshwater ecosystems contain 41% of the world's known fish species.
- Aquatic ecosystems perform many important environmental functions. For example:
  - They recycle nutrients, purify water, attenuate floods, recharge ground water and provide habitats for wildlife.
  - Aquatic ecosystems are also used for human recreation, and are very important to the tourism industry, especially in coastal region.
- There are three basic types of freshwater ecosystems:
  - Lentic: slow-moving water, including Pools, Ponds, and Lakes.
  - Lotic: rapidly-moving water, for example Streams and Rivers.
  - Wetlands: areas where the soil is saturated with water or inundated for at least part of the time

3. Lakes & pond Ecosystem

- A pond is a place where living organisms not only live but interact with biotic & abiotic components.
- Ponds are often exposed to tremendous anthropogenic pressure which significantly affects the system.
- Lakes are usually big standing freshwater bodies.
- They have a shallow water zone called Littoral zone; an open water zone where effective penetration of solar light takes place, called limnetic zone and a deep water zone where light penetration is negligible, called Profoundal zone.

I. Biotic components

1) Producer Organisms

- It includes submerged, free floating and amphibious macrophytes (like; Hydrilla, Utricularia, Wolfia, Azolla, Typha etc.) and minute floating and suspended lower phytoplanktons (like; Ulothrix, Spirogyra, Oedogonium etc.)

2) Consumer Organisms

a) Primary consumers:These are zooplanktons (ciliates, flagellates, other protozoan, small crustaceans) and benthos.

b) Secondary consumers: These are carnivores like insects and fishes feeding on herbivores

c) Tertiary consumers: These are the large fishes feeding on small fishes.

3) Decomposers Micro – organisms like bacteria, fungi and actinomyctes.

II. Abiotic component

- These are the inorganic as well as organic substances present in the bottom soil or dissolved in water. In addition, to the minerals, some dead organic matter is also present.

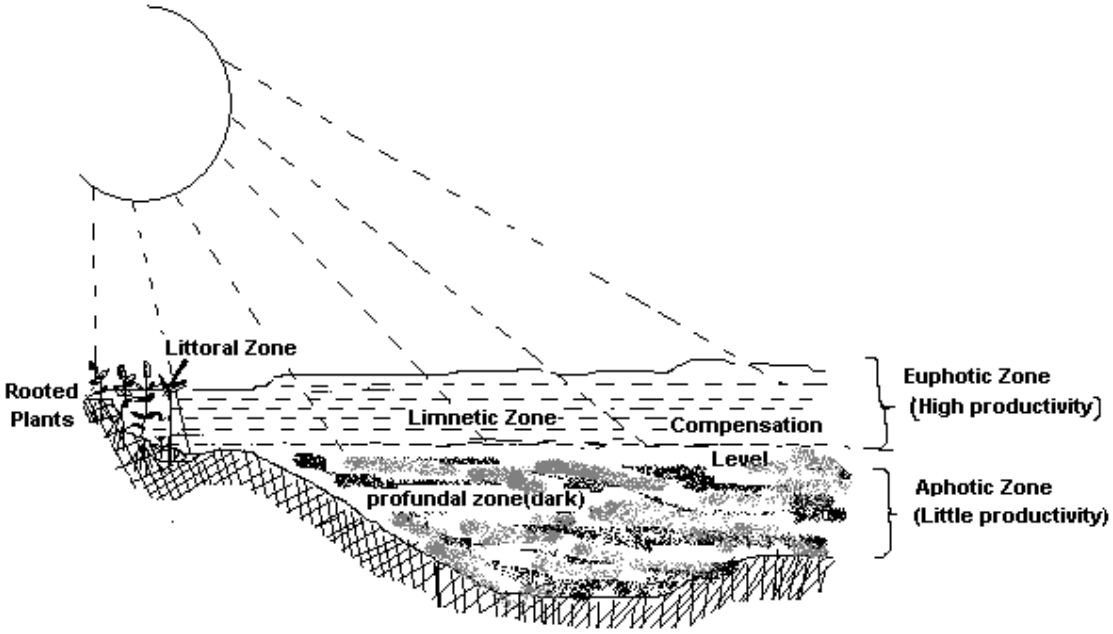


Fig.2.6.4 Zonation in a lake ecosystem

Marine or Ocean Ecosystem

- Marine ecosystems are among the Earth's aquatic ecosystems. They include: Oceans, Estuaries and Lagoons, Mangroves and Coral reefs, the Deep sea and the Sea floor.
- These are the gigantic reservoirs of water covering approximately 71% of the Earth's surface (an area of some 361 million square kilometers).
- These ecosystems are different from freshwater ecosystem mainly because of its salty water.
- The salt concentration in an open sea is usually 3.5% (35 parts per thousand (ppt)). Dominant ions are sodium & chloride.
- Average temperature of Marine ecosystem is 2-3 degree centigrade, devoid of light.

I. Biotic components

1) Producers It includes phytoplanktons (diatoms, dinoflagillates), large seaweeds (mainly algae like chlorophyceae, phaeophyceae & rhodophyceae; angiosperms like Ruppia, Zostera, posidonia), and mangrove vegetation (like Rhizophora, Carapa etc.)

2) Consumers

a) Primary consumers: These are herbivores and feed directly on producers (Crustaceans, Mollusks, fish etc.)

b) Secondary consumers: These are carnivorous fishes (Herring, Sahd and Mackerel)

c) Tertiary consumers: These are top carnivorous fishes (Cod, Haddock, etc.)

3) Decomposers These are micro – organisms like bacteria, fungi

II. Abiotic components

- High Na, Ca, Mg and K salt concentration, variable dissolved oxygen content, light & temperature make a unique physiochemical conditions in marine water.

Fig. Ocean Ecosystem

Bio-diversity

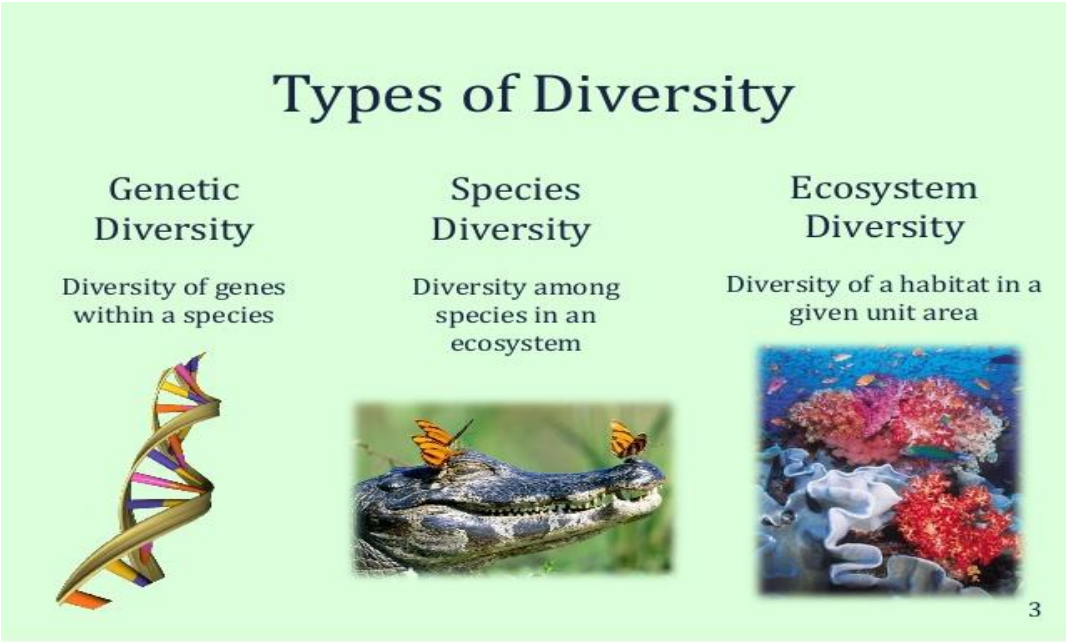
Biodiversity is the variety and differences among living organisms from all sources, including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are a part.

It is virtually synonymous with "Life on earth".

The biodiversity found on Earth today consists of many millions of distinct biological species, which is the product of nearly 3.5 billion years of evolution

Types or Levels of Biodiversity

1) Genetic biodiversity,
2) Species biodiversity,
3) Ecosystem biodiversity



1. **Genetic Biodiversity:**
   - It may be defined as **variability in genes of a particular species in a popu**lation
   - Recombination of gene (DNA) gives rise to some new variety

- Each member of any plant and animals species differ from others due to genetic recombination.
- Today the new varieties created By genetically **manipulation of DNA**

  i) Disease resistant, Drought resistance crops

  ii) Breed superior domestic animals (high yield Caws, plants)

  iii) Better medicines and a variety of industrial products are also developed.

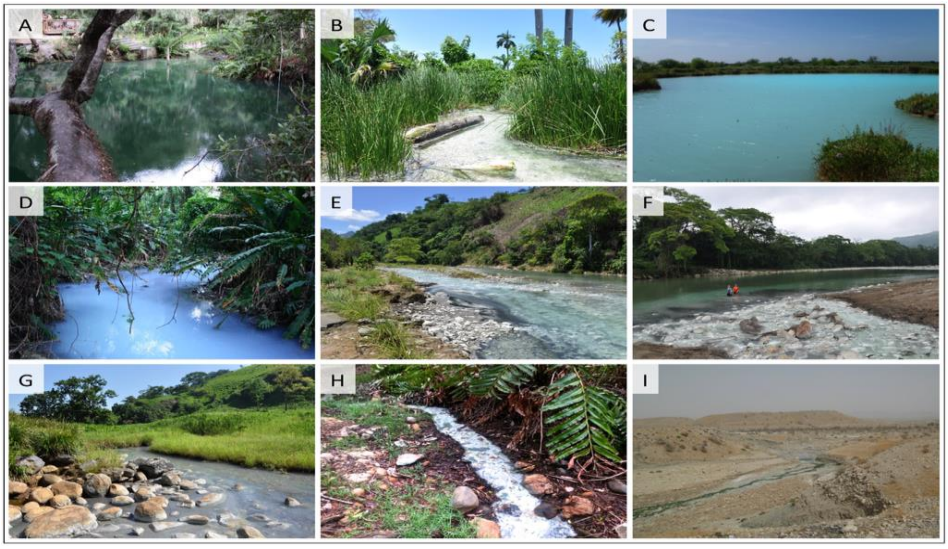
2. Species Biodiversity:

- Refers to the variety of species within a community in a region.
- It an index represents species richness and their abundance in a community.
- At present, about 1.8 million species on Earth.
- India is among the world's 15 Nations that are exceptionally rich in species diversity.
- **Species richness** is simply the number of **species** in a community.
- **Species diversity** is more complex, and includes a measure of the number of **species** in a community, and a measure of the abundance of each **species**.

  Species diversity is usually described by an index, such as Shannon's Index H'.

3. Ecosystem Biodiversity:

- This is the diversity of ecological complexity showing variations in ecological tropic structure, food chain food-webs, nutrient cycling resulted different variety of Ecosystem.
- variations is caused by change in physical parameters like hydrosphere, atmosphere, and lithosphere, moisture, temperature, altitude, precipitation etc.
  E.g. Forest, Grassland, Desert, Pond ecosystems
- **Ecological diversity** is the largest scale of **biodiversity**, and within each **ecosystem**, there is a great deal of both **species** and **genetic diversity**



Values of biodiversity

1. **Direct values (Consumptive uses)**

- Food, fuel, medicines for local community –forest ecosystem.
- Food: Fish, other edible aquatic plants and animals – Marine resources

2. **Productive use value:**

These are the commercially usable values where the product is marketed and sold. 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

- Pharmacist – New and better drugs/medicines
- Raw material for Industry – the paper and pulp industry, Plywood industry, Railway sleeper industry, Silk industry, textile industry, leather industry
- Agricultural – Developing new and better crops with plant breeding

3. **Social Values:**

- Preserved as valuable resource many sacred and holy plants like- based on religion worship: Tulsi, Peepal, and animals like Cow.

4. **Ethical and Moral values:**

- Ethical responsibility to protect all life forms.
- Preservation of nature through local traditions.
- Conservation of biodiversity & economic importance.

5. **Aesthetic Values**:

- Preservation of its inherent value, beauty, aesthetics and creativity for tourist attraction.
- Indian mythology eulogies animals like elephant, snake and cow.
- Enriched biodiversity promotes eco- tourism Industry.

6. **Option Value:**

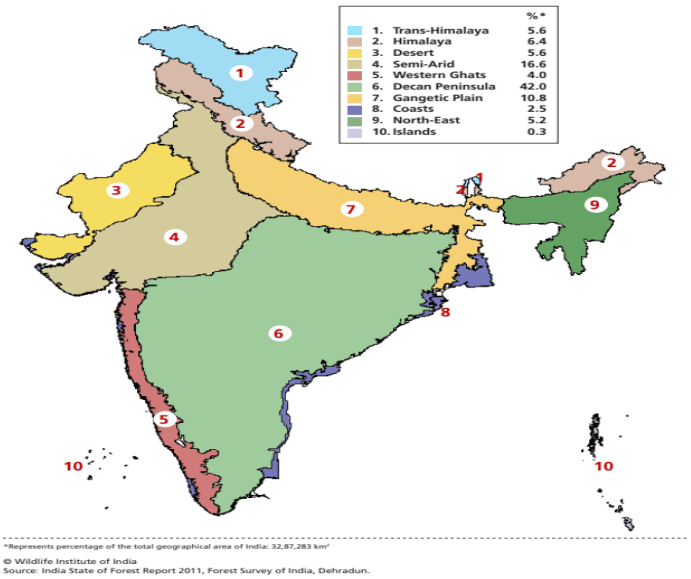
- Keeping future possibilities open for their use is called the option value. In nature many thing yet to explore, plant, microorganism.
- The preservation of biodiversity must also include traditionally used strains already in existence in crops and domestic animals.

Biogeographic classification of India

India is divided in to ten major regions based on geography, climate, vegetation pattern, mammals, birds, reptiles, amphibians, insects and other invertebrates that live in them.

1. The cold mountainous snow covered **Trans-Himalayan region** of Ladakh.
2. The **Himalayan ranges** and Kashmir valley, Himachal Pradesh, Uttarkhand, Assam and other North-eastern states.
3. The **Thar desert** of Rajasthan
4. The **semi-arid** grassland region of Gujurat, Madhya Pradesh
5. The **Western Ghats** in Maharashtra, Karnataka and Kerala.
6. **Deccan plateau** of Chattisgarh, Andhra Pradesh, Karnataka. The North-eastern states of India.
7. **The Gangetic plain** of Bihar, West Bengal
8. The long **western and eastern coastal belt** with sandy beaches, forests and mangroves.
9. The **North-East region** of Manipur, Nagaland
10. The **Andaman and Nicobar Islands**

10 biogeographic zones in India



Biodiversity at Global, National and Local Levels

- 1.8 million known species have been documented. Estimated number of species of plants and animals could be 15-20 billion, that means majority of species are yet to be discovered.
- If biodiversity should form the 'common property resource', to be shared by all nations, there is no reason to exclude oil, uranium or even intellectual and technological expertise as global assets.
- India has a rich biological diversity of flora and fauna.
- Overall 6% of the global species are found in India.
- India ranks 10th among the plant rich countries of the world, 11th in terms of number of endemic species of higher vertebrates, 6th among the centers of diversity and origin of agricultural crops.
- The total number of living species identified in our country is 150,000.

India as a mega-diversity nation

- India is one of the 12 mega-diversity countries in the world. It is among the top 10-15 countries with high biodiversity.
- It is10th among the plant rich countries of the world and 4th among the Asian countries.
- 350 mammal species – 8th in the world
- 1200 bird species – 8th in the world
- 453 reptile species -5th in the world
- 45,000 plant species – 15th in the world
- 18% Indian plants are endemic to the country and found nowhere in the world
- 62% amphibians are endemic
- 50% of the lizards are endemic
- Gene banks have collected - 34,000 cereals
  - 22,000 pulses
  - 27 breeds of cattle
  - 40 breeds of sheep
  - 22 breeds of goat
  - 8 breeds of buffalos

Many of these are dying out due to misguided adoption of all foreign things.

MOEF is the nodal agency for implementation of CBD in India.
National Biodiversity Action Plan (NBAP) was formulated in 2007

Why is India a mega diversity nation?

- Nearly 5000 species of flowering plants, 166 species of crop plants and 320 species of wild relatives of cultivated crops have their origin in India.
- Marine diversity: Along 7500 km long coastline has more than 340 species of corals and is rich in mollusks, crustaceans (crabs etc.).
- Several species of Mangrove plants and sea grasses (Marine algae).
- 93 major wet lands, coral reefs and mangroves need to be studied.
- Indian forests cover 64.01 million hectares having a rich biodiversity of plants in the Trans-Himalayan, north-west, west, central and eastern Himalayan forests, western ghats, coasts, deserts, Gangetic plains, deccan plateau and the Andaman, Nicobar and Lakshadweep islands.

Threats to Biodiversity

There are different threats to biodiversity because of which their population is going on decreasing day by day. The threats may be natural on anthropogenic. Some of the causes are discussed below;

1. **Habitat loss, degradation, fragmentation.**

Habitat loss & degradation are major causes of species extinction, affecting 89% of all threatened birds, 83% of mammals & 91% of all threatened plants assessed globally (IUCN, 2000).

The main causes of habitat loss are agriculture activities, mining, large hydro power plants, development of human settlement area and industry etc.

2. **Poaching of wildlife**

Poaching is another threat that has emerged in recent decades as one of the primary reason for decline in number of species.

Wildlife is sold and traded in many countries for live specimens, folk medicines, furs, skin, and other products such as ivory, horns etc. amounting to millions of dollars.

3. **Man – wildlife conflicts**

Due to the lack of stable food and disruption of movement, wild animals came out of forest area and attack the agricultural field and humans and in turn got killed by the humans.

4. **Introduction of exotic species**

Organisms introduced into new habitats where they are not native are termed as exotics are also considered as Biological Pollutants.

5. **Climate change and environmental pollution**

A changing global climate threatens species and ecosystems.

The air, water and soil pollution are the major factor to extinct number of species in both terrestrial and aquatic ecosystems.

Endangered and Endemic species in India

According to The International Union of Conservation of Nature and Natural Resources (IUCN), the species that considered in imminent danger of extinction and whose survival is unlikely, if factors causing their decline continue to operate.

- Out of about 47,000 species of plants in our country, 7000 are endemic.
- In India, 53 species of mammals, 69 birds, 23 reptiles and 3 amphibians are considered as threatened species.
- As many as 3,000- 4,000 higher plants may be under high degree of threat in India.
- **Red Data Book of IUCN(International Union for Conservation of Nature and Natural Resources, 1964)**

Classification of plant and animal as per Red Data Book

- **Endangered (E)**

  Species whose numbers have been reduced to a critical level or whose habitats have been so drastically reduced that they are deemed to be in immediate danger of extinction.

- **Vulnerable (V)**

Species believed likely to move into the endangered category in the near future if the casual factors continue operating.

- **Rare (R)**

  Species with, small world populations that are not at present endangered or vulnerable, but are at risk.

- **Threatened (T)**

  Threatened is used in the conservation context for species which are in one of the categories Endangered, Vulnerable and Rare.

- **Out of danger (O)**

  Species formerly included in one of the above categories, but which are now considered relatively secure because effective conservation measures have been taken

- **Inderterminate (I)**

  Species that is suspected of belonging to one of the first three categories, but for which insufficient information is currently available.

Conservation of biodiversity

The convention on Biological Diversity held in June, 1992 stressed the need of the conservation of Biodiversity for sustainable development.

Conservation is defined as "the management of human use of the biosphere so that it may yield the greatest sustainable benefit to the present generation while maintaining its potential to meet the needs and aspirations of the future generations".

The two basic approaches to wildlife conservation in protected habitats are:

1) In- Situ conservation 2) Ex- Situ conservation.

In- Situ conservation It simply means conservation of species in its natural ecosystem or habitat through a network of "protected area".

Protected Areas: an area of land and/or sea specially dedicated to the protection and maintenance of biological diversity and managed through legal effective means.

These include:-

- Biosphere reserves
- National parks
- Wild Life Sanctuaries etc.

Biosphere Reserves

Biosphere Reserves have been described as undisturbed natural areas for scientific study as well as areas in which conditions of disturbance are under control. These serve as the centre for ecological research and habitat protection, The "Biosphere Reserve consists of two main zones as:

1. Core zone (undisturbed area)
2. Buffer zone(open for tourism)

Indian Government has established 18 Biosphere Reserves. The main objectives of the programme are as follows:

• Conserve biological diversity

• Safeguard genetic diversity

• Provide areas for basic and applied research

• Opportunity for Environmental Science and training

• Promote international cooperation

• Promote management of biotic resources.

National Parks

According to the Indian Board for Wild Life (IBWL), “A National Park is an area dedicated by statute for all time to conserve the natural scenery and historical objects to conserve the wild

life there in and to provide for enjoyment of the same in such manner and by such means, that will leave them undisturbed for the enjoyment of future generations .

India's first national park was established in 1936 as Hailey National Park, now known as Jim Corbett Natioal Park.

In 1972, India enacted the Wildlife Protection Act and Project Tiger to safeguard the habitats of conservation reliant species.

10 Top National Parks of India

- Kanha National Park – Madhya Pradesh
- Bandhavgarh National Park - Madhya Pradesh
- Kaziranga National Park - Assam
- Nagarhole National Park - Karnataka
- Ranthambhore National Park - Rajasthan
- Periyar National Park - Kerala
- Gir National Park - Gujrat
- Sunderbans National Park – West Bengal
- Sariska National Park – Rajasthan

Wildlife sanctuary

The Indian Board for Wild Life has defined a sanctuary as, 'An area where killing, hunting, shooting or capturing of any species of bird or animal is prohibited except by or under the control of highest authority in the department responsible for the management of the sanctuary and whose boundaries and character should be sacrosanct as far as possible.

Examples of some Wild Life Sanctuaries of India:

- Ghana Bird sanctuaries
- Hazaribagh sanctuaries

- Abohar wild life sanctuaries
- Jaldapara wild life sanctuaries
- Mudamalai wild life sanctuaries

Ex- Situ conservation

It is defined as "the conservation of component of biological diversity (Sample of genetic diversity, particularly of endangered species) outside their natural habitats".

1. **Botanical/ zoological gardens, aquarium and research centre.**

There are more than 1500 Botanical gardens in the world containing more than 80,000 species. There are more than 800 zoos around the world with about 3,000 species of mammals, birds, reptiles and amphibians.

2. **Field Gene Banks**

These are places where wide varieties of plant are growing in order to maintain the widest range of biodiversity.

3. **Seed Banks**

These are most efficient and effective method of Ex-Situ conservation of plants whose seeds are suitable for long term storage.

Organizations working for protection of biodiversity

- India's Department of Environment functions as the nodal agency for United National Environment Programme (UNEP)
- The South Asia Cooperation Environment Programme (SACEP)
- The International Union for Conservation of Nature and Natural Resource (IUCN)
- India has been actively participating in the various sessions of UNEP with a view to ensure that programmes are more relevant to the developing countries.

Biodiversity Hotspot

A biodiversity hotspot is a biogeographic region with significant levels of species richness, high species endemism and biodiversity that is threatened by human habitation.

To be classified as a **biodiversity hotspot**, a region must have lost at least 70 percent of its original natural vegetation, usually due to human activity.

There are over 30 recognized **biodiversity hotspots** in the world

Biodiversity hotspots in India

- India hosts 4 biodiversity hotspots**: the Himalayas, the Western Ghats, the Indo-Burma region and the Sundaland (Includes Nicobar group of Islands).** These hotspots have numerous endemic species.
- The Himalayas is the prime hotspot for biological diversity in India
- India is considered a mega diversity hotspot because of the large diversity of organism found here ranging from eastern to Western Ghats and North and South India too. Mainly Western Ghats are at high risk now.

Air Pollution

1. Causes of pollution

Pollution is the effect of undesirable changes in our surroundings that have harmful effects on plants, animals and human beings. Two basic problems result from the consumption of resources for our energy requirement.

i. Resource Crunch

That results from irreparable depletion of resources exceeding the carrying capacity of resources.

ii. **Environmental degradation**

That results from imbalances of our Ecosystem exceeding the assimilating ability of ecosystem there by causing degradation in environment.

2. Environmental degradation causes various pollution problems.

- Degradation in air environment causes air pollution problem.
- Degradation in noise environment causes noise pollution problem.
- Degradation in water environment causes water pollution problem.
- Dumping of solid waste on land causes land pollution problem.
- Pollution affects the flora and fauna in various ways causing ecological Pollution problem.

3. Nature of pollutants

In general, the pollutants can be classified depending on the degradation of them in the environment.

i. Degradable pollutants: Easily degradable, easily decomposed to simpler compounds by means of biodegradation and physico-chemical degradation. Most of the wastes released by living beings are biodegradable. Most of the wastes in our daily use are easily degradable.

ii. Difficultly degradable: These wastes are not easily degradable. They take a long time to degrade. Examples are plastic waste, chlorofluorocarbon, some pesticides etc.

iii. **Non-degradable:** These wastes are not degradable to simpler compounds. Examples are metallic waste. Toxic heavy metals like lead, mercury, cadmium, chromium, nickel etc. will always remain the same metal and hence toxic.

4. History of air pollution

The origin of air pollution on the earth can be traced from the times when man started using firewood as a means of cooking and heating. Hippocrates has mentioned air pollution in 400 BC. With the discovery and increasing use of coal, air pollution became more pronounced especially in urban areas. It was recognized as a problem 700 years ago in London in the form of smoke pollution, which prompted King Edward I to make the first antipollution law to restrict people from using coal for domestic heating in the year 1273. In the year 1300 another Act banning the use of coal was passed. Defying the law led to imposition of capital punishment. In spite of this air pollution became a serious problem in London during the industrial revolution due to the use of coal in industries. The earliest recorded major disaster was the 'London Smog' that occurred in 1952 that resulted in more than 4000deaths due to the accumulation of air pollutants over the city for five days. Pollutants are also found indoors from infiltration of polluted outside air and from various chemicals used or produced inside buildings. Both indoor and outdoor air pollution are equally harmful.

5. Atmospheric useful gases and air pollutants

Oxygen is required for human respiration (metabolic requirements). Oxygen is required for wild fauna in natural ecosystems and domestic animals used by man as food. Oxygen is a part of carbon dioxide; oxygen used for the photosynthetic activities of plants and prepares the first food of ecosystem. The atmosphere forms a protective shell over the earth. It is a complex dynamic system. If its nature is disrupted it affects all mankind. Most air pollutants have both global and regional effects. Living creatures cannot survive without air even for a span of a few minutes. To continue to support life, air must be kept clean. Major pollutants of air are created by industrial units that release various gases such as carbon dioxide, carbon monoxide and toxic fumes into the air. Air is also polluted by burning fossil fuels. The buildup of carbon dioxide which is known as greenhouse effect' in the atmosphere is leading to current global warming. The growing number of scooters, motorcycles, cars, buses and trucks which run on fossil fuel (petrol and diesel) is a major cause of air pollution in cities and along highways. Air pollution leads to acute and chronic respiratory diseases such as various lung infections, asthma and even cancer.

6. Types of air pollutants

Depending upon the occurrence, chemical nature and physical state etc. the air pollutants are classified into following category

Natural air pollutants

The various air pollutants are occurring naturally. But their occurrence is few and far between so as to cause significant air pollution problem.

- **Lightening:** Atmospheric nitrogen and oxygen can react at high temperature of lightening and cause nitrogen oxide and nitrogen dioxide pollution
- **Forest fire:** Fire remnants of forest have the air pollution in the form of particulates, unburnt hydrocarbon, carbon monoxide and some toxic pollutants
- **Volcanic eruptions:** Molten lava has the sulfur converted to sulfur dioxide that causes SO_2 pollution

Anthropogenic air pollutants

- **Use of fossil fuel** like coal, crude oil, petroleum products cause air pollution in the form of particulate pollution, SO_2 , NO_X , CO, CO_2 and other toxic pollutants
- **Vehicular pollution:** particulate, CO and NO_X
- **Mineral excavation and beneficiation:** particulate pollution
- Transportation: SO_2 , NO_X , CO, CO_2 and other hazardous pollutants
- **Loading and unloading:** Particulate pollution

Primary air pollution

• Pollutants that are emitted directly from identifiable sources are produced both by natural and anthropogenic events.

Examples are SO_2, NO, NO_2, CO, CO_2, Particulates classified as PM 10 (Particle size.<= 10 micron) PM 2.5 (Particle size .<= 2.5 micron)

Secondary air pollution

• Pollutants that are formed by atmospheric chemical combination among the primary pollutants and others

Examples are acid rain, photochemical smog [Peroxy Acyl Nitrate (PAN)] etc.

Hydrocarbons + NO_X + Sunlight = PAN

Gaseous air pollutants

These include gases mostly released from burning of fossil fuels. These are oxides of carbon (CO, CO_2), oxides of sulfur (SO_2, SO_3) , oxides of nitrogen (NO, NO_2).

Besides other common gaseous pollutants include are hydrogen sulfide (H_2S), ozone (O_3) and ammonia (NH_3) etc.

Particulate air pollutants

These include dust particles from various activities. When the particle remains in suspension in air is generally referred to as suspended particulate matter (SPM) and is a common particulate pollution. The SPM is usually known as particulate matter (PM) or aerosol. The finer particulates are important from health point of view. Particulate size less than 10 microns is known as PM10 and size less than 2.5 micron is known as PM2.5. These small size PM values are enlisted in National ambient air quality standards (NAAQS).

Besides technical names PM10 and PM2.5, the popular names of particulate

• Aerosol: General term for particles suspended in air.

• Mist: Aerosol consisting of liquid droplets Sulfuric acid mist

• Dust: Aerosol consisting of solid particles that are blown into Dust storm the air or are produced from larger particles by grinding them down

• Smoke: Aerosol consisting of solid particles or a mixture of solid Cigarette smoke, smoke and liquid particles produced by chemical reaction such from burning garbage as fires

• Fume: Generally means the same as smoke but often applies Zinc/lead fumes specifically to aerosols produced by condensation of hot vapors of metals.

• Plume: Geometrical shape or form of the smoke coming out of a chimney

• Fog: Aerosol consisting of water droplets

• Smog Term used to describe a mixture of smoke and fog

7. Dispersion of pollutants into atmosphere

One of the most effective and commonly adopted processes of air pollution control is to disperse air pollutants into atmosphere which acts as a great sink. The pollutants are effectively diluted and the ground level concentration comes to an acceptable level. The various factors affecting this dispersion process are mentioned here under.

Meteorological factors affecting dispersion process are

- Wind speed
- Wind direction
- Topography
- Humidity of air
- Atmospheric pressure
- Atmospheric lapse rate
- Cloud cover
- Solar insolation
- Atmospheric temperature

Anthropogenic factors affecting dispersion process are

- Position of the emitting source
- Height of the stack
- Concentration of the pollutant in flue gas
- Flue gas temperature
- Flue gas flow

- Flue gas velocity

8. Effects of air pollution

i. Effects on living organisms

Our respiratory system has a number of mechanisms that helps in protecting us from air pollution. The hair in our nose filters out larger particles. The sticky mucus in the lining of the upper respiratory tract captures smaller particles and dissolves some gaseous pollutants. When the upper respiratory system is irritated by pollutants sneezing and coughing expel contaminated air and mucus. Prolonged smoking or exposure to air pollutants can overload or break down these natural defenses causing or contributing to diseases such as lung cancer, asthma, chronic bronchitis and emphysema. Elderly people, infants, pregnant women and people with heart disease, asthma or other respiratory diseases are especially vulnerable to air pollution. Cigarette smoking is responsible for the greatest exposure to carbon monoxide. Exposure to air containing even 0.001 percent of carbon monoxide for several hours can cause collapse, coma and even death. As carbon monoxide remains attached to hemoglobin in blood for a long time, it accumulates and reduces the oxygen carrying capacity of blood. This impairs perception and thinking, slows reflexes and causes headaches, drowsiness, dizziness and nausea. Carbon monoxide in heavy traffic causes headaches, drowsiness and blurred vision. Sulfur dioxide irritates respiratory tissues. Chronic exposure causes a condition similar to bronchitis. It also reacts with water, oxygen and other material in the air to form sulfur-containing acids. The acids can become attached to particles which when inhaled are very corrosive to the lungs.

Nitrogen oxides especially NO_2 can irritate the lungs, aggravate asthma or chronic bronchitis and also increase susceptibility to respiratory infections such as influenza or common colds. Suspended particles aggravate bronchitis and asthma. Exposure to these particles over a long period of time damages lung tissue and contributes to the development of chronic respiratory disease and cancer. Many volatile organic compounds such as (benzene and formaldehyde) and toxic particulates (such as lead, cadmium) can cause mutations, reproductive problems or cancer. Inhaling ozone, a component of photochemical smog, causes coughing, chest pain, breathlessness and irritation of the eye, nose and the throat.

ii. Effects on plants

When some gaseous pollutants enter leaf pores they damage the leaves of crop plants. Chronic exposure of the leaves to air pollutants can breakdown the waxy coating that helps prevent excessive

water loss and leads to damage from diseases, pests, drought and frost. Such exposure interferes with photosynthesis and plant growth, reduces nutrient uptake and causes leaves to turn yellow, brown or drop off altogether. At a higher concentration of Sulphur dioxide majority of the flower buds becomes stiff and hard. They eventually fall from the plants, as they are unable to flower. Prolonged exposure to high levels of several air pollutants from smelters, coal burning power plants and industrial units as well as from cars and trucks can damage trees and other plants.

iii. Effects on materials

Every year air pollutants cause damage worth billions of rupees. Air pollutants break down exterior paint on cars and houses. All around the world air pollutants have discolored irreplaceable monuments, historic buildings, marble statues, etc.

9. Effects of air pollution on the stratosphere

The upper stratosphere consists of considerable amounts of ozone, which works as an effective screen for ultraviolet light. This region called the ozone layer extends up to 60 km above the surface of the earth. Though the ozone is present up to 60 km its greatest density remains in the region between 20 to 25 km. The ozone layer does not consist of solely ozone but a mixture of other common atmospheric gases. In the densest ozone layer there will be only one ozone molecule in 100,000 gas molecules. Therefore, even small changes in the ozone concentration can produce dramatic effects on life on earth. The total amount of ozone in a 'column' of air from the earth's surface up to an altitude of 50 km is the total column ozone. This is recorded in Dobson Units (DU), a measure of the thickness of the ozone layer by an equivalent layer of pure ozone gas at normal temperature and pressure at sea level. This means that 100DU=1mm of pure ozone gas at normal temperature and pressure at sea level. Ozone is a form of oxygen with three atoms instead of two. It is produced naturally from the photo dissociation of oxygen gas molecules in the atmosphere. The ozone thus formed is constantly broken down by naturally occurring processes that maintain its balance in the ozone layer. In the absence of pollutants, the creation and breakdown of ozone are purely governed by natural forces, but the presence of certain pollutants can accelerate the breakdown of ozone. Though it was known earlier that ozone shows fluctuations in its concentrations which may be accompanied sometimes with a little ozone depletion, it was only in 1985 that the large scale destruction of the ozone also called the Ozone Hole came into limelight when some British researchers published measurements about the ozone layer. Soon after these findings a greater impetus was given to research on the ozone layer, which convincingly

established that CFC's were leading to its depletion. These CFCs (chlorofluorocarbons) are extremely stable, non-flammable, non-toxic and harmless to handle. This makes them ideal for many industrial applications like aerosols, air conditioners, refrigerators and fire extinguishers. Many cans, which give out foams and sprays, use CFCs. (eg: perfumes, room fresheners etc.) CFCs are also used in making foams for mattresses and cushions, disposable Styrofoam cups, glasses, packaging material for insulation, cold storage etc. India has signed the Montreal Protocol in 1992, which aims to control the production and consumption of Ozone Depleting Substances. Changes in the ozone layer have serious implications for mankind.

i. Effects on human health:

Sunburn, cataract, aging of the skin and skin cancer are caused by increased ultra-violet radiation. It weakens the immune system by suppressing the resistance of the whole body to certain infections like measles, chicken pox and other viral diseases that elicit rash and parasitic diseases such as malaria introduced through the skin.

ii. Food production:

Ultra violet radiation affects the ability of plants to capture light energy during the process of photosynthesis. This reduces the nutrient content and the growth of plants. This is seen especially in legumes and cabbage. Plant and animal planktons are damaged by ultra- violet radiation. In zooplanktons (microscopic animals) the breeding period is shortened by changes in radiation. As planktons form the basis of the marine food chain a change in their number and species composition influences fish and shell fish production.

iii. Effect on materials:

Increased UV radiation damages paints and fabrics, causing them to fade faster.

iv. Effect on climate:

Atmospheric changes induced by pollution contribute to global warming, a phenomenon which is caused due to the increase in concentration of certain gases like carbon dioxide, nitrogen oxides, methane and CFCs. Observations of the earth have shown beyond doubt that atmospheric constituents such as water vapour, carbon dioxide, methane, nitrogen oxides and Chloro Fluro Carbons trap heat in the form of infra-red radiation near the earth's surface. This is known as the '**Greenhouse Effect'**. The phenomenon is similar to what happens in a greenhouse. The glass in a greenhouse allows solar

radiation to enter which is absorbed by the objects inside. These objects radiate heat in the form of terrestrial radiation, which does not pass out through the glass. The heat is therefore trapped in the greenhouse increasing the temperature inside and ensuring the luxuriant growth of plants. There could be several adverse effects of global warming.

- With a warmer earth the polar ice caps will melt causing a rise in ocean levels and flooding of coastal areas.

- In countries like Bangladesh or the Maldives this would be catastrophic. If the sea level rises by 3m., Maldives will disappear completely beneath the waves.

- The rise in temperature will bring about a fall in agricultural produce.

- Changes in the distribution of solar energy can bring about changes in habitats. A previously productive agricultural area will suffer severe droughts while rains will fall in locations that were once deserts. This could bring about changes in the species of natural plants, agricultural crops, insects, livestock and micro-organisms.

- In the Polar Regions temperature rises caused by global warming would have disastrous effects. Vast quantities of methane are trapped beneath the frozen soil of Alaska. When the permafrost melts the methane that will be released can accelerate the process of global warming.

National Ambient Air Quality Standard (NAAQS)-2009

It was notified on 16-11-2009 by government of India. Some of the important air quality parameters are mentioned in the table

Pollutant parameter	unit	Averaging	Concentration in ambient air	
			Industrial/residential area	Ecologically sensitive area
Sulfur dioxide	$\mu g/m^3$	24 hourly	80	80
Nitrogen dioxide	$\mu g/m^3$	24 hourly	80	80
Particulate PM10	$\mu g/m^3$	24 hourly	100	100
Particulate PM2.5	$\mu g/m^3$	24 hourly	60	60
Carbon monoxide	$\mu g/m^3$	8 hourly	2000	2000
ozone	$\mu g/m^3$	8 hourly	100	100

10.Air quality monitoring

India does not presently have a well-established system of monitoring air pollution. When air quality monitoring began in India in the late 1960s planners focused only on a few pollutants namely sulfure dioxide, nitrogen oxides and suspended particulate matter. Pollutants such as carbon monoxide and lead were monitored only on a limited scale. The threat from other air toxins such as benzene, ozone, and other small particulates is not known as these are not monitored at all. A database on ambient air quality in Indian cities has been prepared by the monitoring networks of the National Environmental Engineering Research Institute (NEERI), Nagpur. The Central Pollution Control Board (CPCB) initiated its own national Ambient Air Quality Monitoring (NAAQM) program in 1985. Data to the NAAQM is supplied by the respective state pollution control boards, which is then transmitted to the CPCB. Experts feel that the present air quality-monitoring network cannot capture the true profile of urban air pollution due to the lack of adequate monitoring stations. Moreover, critical toxins have still not been included in the list of pollutants to be monitored.

11. Air pollution Control

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

i. Gaseous pollutant control measure

Gaseous pollutants are mostly chemical in nature. Chemical methods are commonly used in this control measures.

Condensation: It involves removing heat from hot gas stream to reduce the temperature so that some of the pollutant like ammonia get condensed and so can be easily removed.

Absorption: It involves transfer of pollutant from gas stream to liquid stream. Examples are removal of ammonia by water, hydrogen sulphide by sodium hydroxide etc.

Adsorption: It involves transfer of pollutant from gas stream to solid surfaces having desirable surface properties.

Flue gas desulphurization: It involves removal of SO_2 from the flue gas NO_X emission control: It involves various techniques for the removal of NO and NO_2 (NO_X).

Incineration: It is a high temperature combustion process. It is suitable for destruction of hazardous substances.

ii. **Particulate pollution control measure**

Because of the particle dynamics, the control measures are entirely different from gaseous pollutant. The output results are viewed with the collection efficiency of particular equipment. The control measures are settling chambers, cyclone separators, bag filters, electrostatic precipitators and scrubbers.

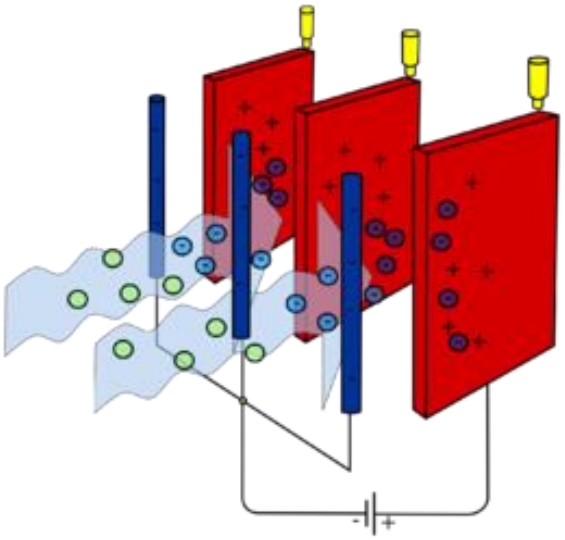
Particulate pollution control

Pollution control methods	Removal mechanism	Particle size removal	efficiency	Design parameters
Gravity settling chamber	Gravity	>50 μ	>50%	-
Cyclone separator	Centrifugal forces and gravity	>5 μ	>85%	-
Bag filter	Interception, impaction and diffusion	< 0.1 μ	>99%	Air to cloth or filtering ratio 0.5 to 5 m/minute
Electrostatic precipitator (ESP)	Electrostatic forces of attraction	< 0.1 μ	>99%	

A. Electrostatic precipitator (ESP)

An electrostatic precipitator is a filtration device that removes fine particles, like dust and smoke, from a flowing gas using the force of an induced electrostatic charge minimally impeding the flow of gases through the unit.

The operation of electrostatic precipitators is fairly simple. The dirty flue gas escaping through the smokestack is passed through two electrodes. The shape these electrodes depends on the type of electrostatic precipitator used, but they can be metal wires, bars, or plates inside a pipe or the smokestack itself. One of the electrodes is charged with a high negative voltage, and this plate causes particulates inside the smoke to obtain a negative charge as they pass by this electrode. Further along the pipe, the second electrode carries a similarly high positive voltage. Based solely on the fact that opposite charges attract, the negatively charged soot particles are pulled towards the positive electrode and stick to it. Occasionally these plates must be cleaned to remove the accumulated soot and dispose of it into a hopper. The soot and ash collected from coal burning power plants in this manner is referred to as fly ash.



Example 1: Compute the plate area of ESP handling a flow of 3600 m^3/min. The particulate velocity is taken as 0.15 m/s and efficiency of ESP as 99%.

Solution: $\eta = 1 - \exp(-Aw/Q)$

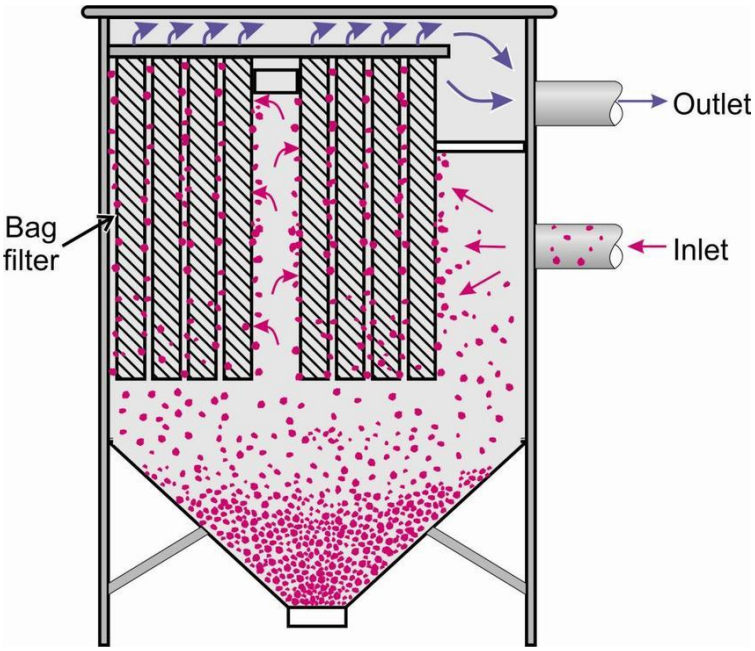
[A = Total area of the plates; w = Settling velocity; Q = Flow rate]

$0.99 = 1 - \exp(-0.15 \times A/3600/60)$

A = Area of plate = 1842.1 m

B. Baghouse filters

One of the most efficient devices for removing suspended particulates is an assembly of fabric-filter bags, commonly called a baghouse. A typical baghouse comprises an array of long, narrow bags—each about 25 cm (10 inches) in diameter—that are suspended upside down in a large enclosure. Dust-laden air is blown upward through the bottom of the enclosure by fans. Particulates are trapped inside the filter bags, while the clean air passes through the fabric and exits at the top of the baghouse. A fabric-filter dust collector can remove very nearly 100 percent of particles as small as 1 μm and a significant fraction of particles as small as 0.01 μm.



Example 2: A bag house is to be constructed using bags of 0.25 m diameter and 6 m long. It is to receive 15 m^3 /s of air. Assuming the filtration rate of 2.2 m/min. Determine the no bags required in the bag house.

Solution: Total filtration area required= gas flow rate/filtration rate

= 15 X 60 m^3/min/2.2 m/min = 409.1 m^2

Area of one bag = π X D X H= 3.14 X 0.25 X 6 = 4.71 m^2

No. of bags required in bag house = 409.1/4.71 = 86.8 that is 87 bags

Water Pollution

Definition

- Water pollution means undesirable changes in physical, chemical or biological properties of water that makes it unfit for use by human and other living beings.
- There are certain symptoms of water pollution: changed colour, offensive smell, bad taste, unchecked growth of aquatic weeds, oily material floating on surface, and death of fish and other aquatic organisms.

Important Facts on Water pollution

- Only about 3% surface water is fresh water
- One fifth of the world's population lacks the access of clean water
- Over 2.6 billion people do not have adequate toilets.
- More than 2 million children are killed by diarrheal diseases each year
- Demand of water will double in next 30 years

Causes of Water Pollution

Water is uniquely vulnerable to pollution. Known as a "universal solvent," water is able to dissolve more substances than any other liquid on earth. That's why water is so easily polluted. Toxic substances from farms, towns, and factories readily dissolve into and mix with it, causing water pollution.

Water pollutants: Types

Water pollutants have been classified into following categories:

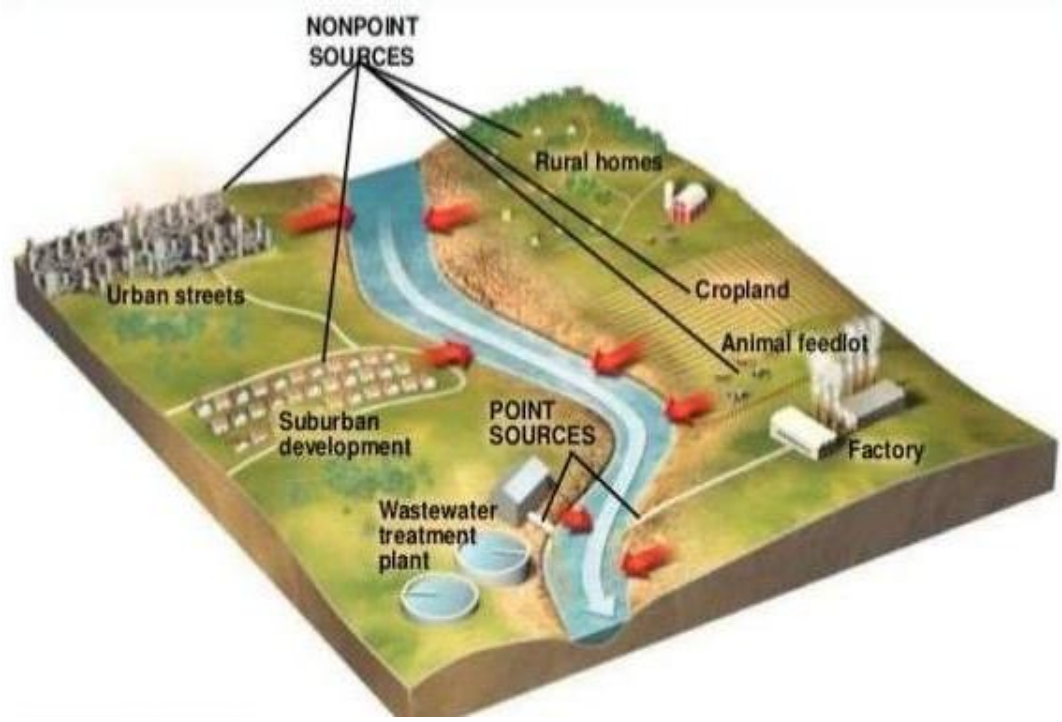
- **Organic pollutants:** Majority of them are derivatives of living beings while some compounds are synthetic. They include (a) Natural organic pollutants, (b) Sewage and industrial effluents, (c) Synthetic organic chemicals (SOCs), (d) Microbiological pollutants, and (e) Oils.
- **Inorganic pollutants:** These include variety of inorganic chemicals like mineral acids, bases, salts, metals, heavy metals etc. They come from natural sources (rocks) as well as manmade sources (industries).
- **Radioactive pollutants:** These include different radioactive substances which are released into water from natural sources (rocks) as well as manmade sources (nuclear waste, weapons etc.).
- **Suspended solids and sediments:** These include insoluble impurities like soil, sand and other solid particles which either remain as suspension in water or form sediments. Sources

include soil erosion (by agriculture, mining, construction), sewage and other effluents.

- **Heat or thermal pollution:** Heated water from thermal power plants and industries is often discharged in water bodies. This increases temperature of water and decreases dissolved oxygen.

Sources of water pollution

- Major sources of water pollution include: Nature (death and decay of plants and animals), soil erosion, agricultural run-off, mining (acid mine drainage), municipal sewage, industrial effluents, accidental spillage etc.
- There are two types of sources of water pollution:
  - **Point sources:** Sources whose location can be identified as single point. e.g., sewage and industrial effluent
  - **Non-point or diffused or area sources:** Sources that are scattered over a large area or that cannot be identified as single point. e.g., run-off from agricultural land, forests, construction etc



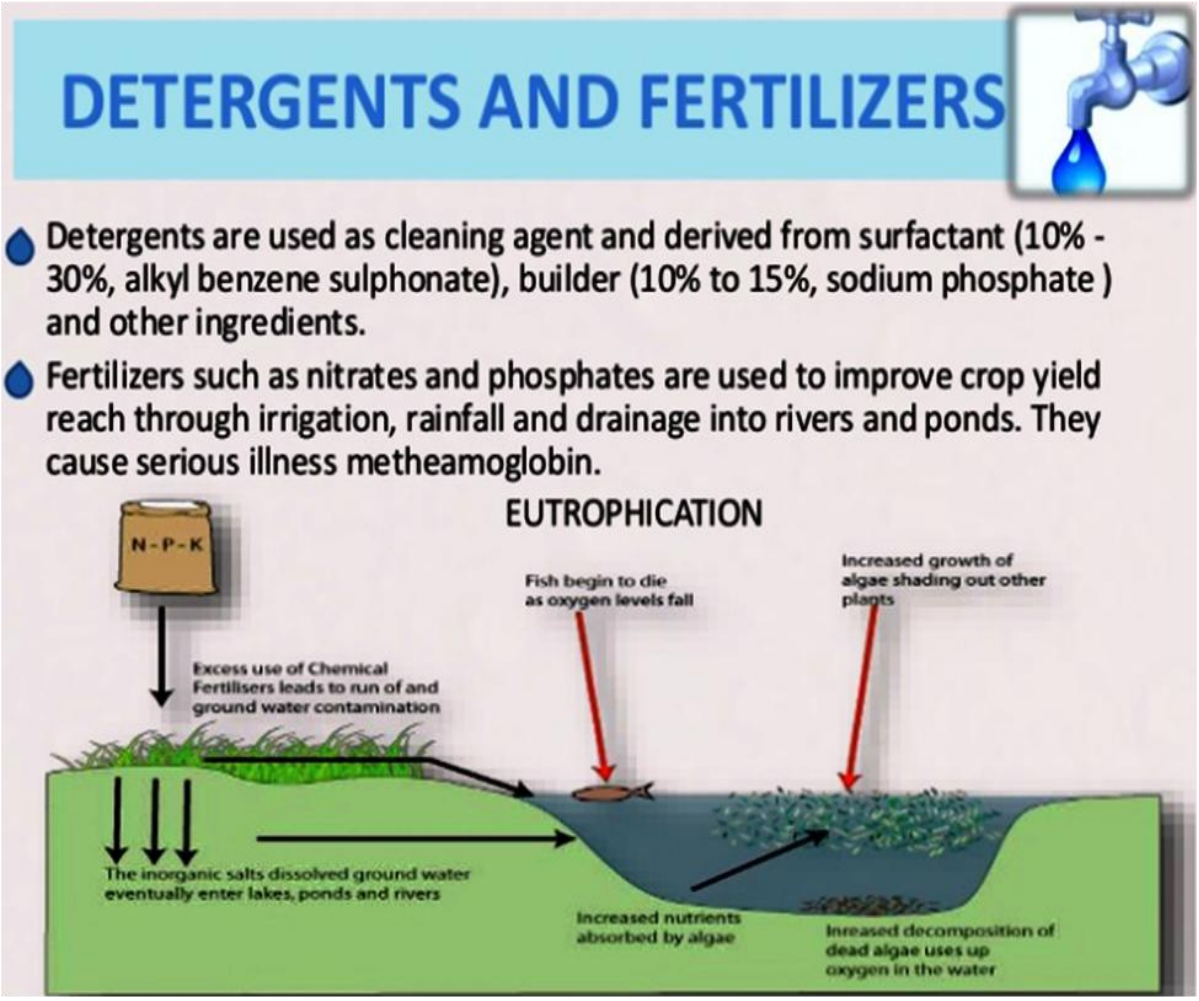
Effects of water pollution

Water pollution has following types of adverse effects on properties of water:

- **Physical effects:** It includes increased temperature, depletion of dissolved oxygen (DO), increased turbidity, altered colour, oily surface etc. This results in reduced photosynthesis and loss of aquatic life.
- **Oxidation effects:** It includes biological and chemical oxidation. As a result of this

different impurities get oxidized (e.g., sulphides into sulphate, ammonia into nitrite and nitrates) at the cost of dissolved oxygen.

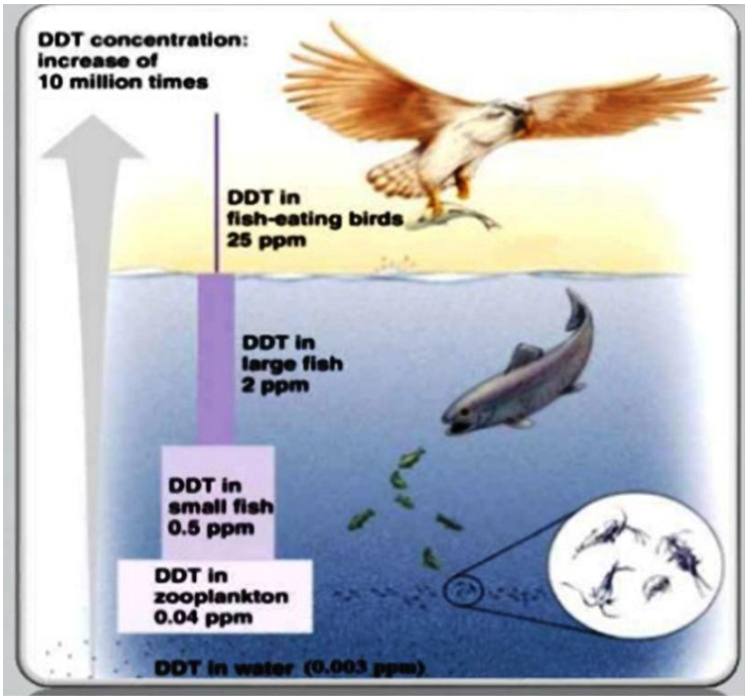
- **Toxic chemical effects:** This includes poisonous effects of different compounds which results into fatal diseases or deaths of living beings. e.g., toxic metals like cadmium, mercury, chromium cause damage to liver, kidney and brain. Similarly pesticides, acids, dioxins cause damage.
- **Nutrient effects and Eutrophication:** Agricultural run-off brings lots of nutrients (nitrates and phosphates) to water bodies. This results into excessive growth of water weeds (chiefly algae) all over the surface and death of underlying organisms due to oxygen shortage. Finally the aquatic ecosystem collapse (destroyed). This is called Eutrophication.
- **Micro-organism effects:** Different micro-organisms (e.g., bacteria, virus) found in dirty water cause a number of water borne diseases e.g., cholera, typhoid, hepatitis, dysentery etc.



Industrial Wastes and Effluents

- Industrial wastes and their effluents include poisonous materials like acids, alkalis, salts, phenols, cyanides, zinc, insecticides which make water toxic and deoxygenated and eventually do not support aquatic life.
- Mercury causes Minamata disease
- Oils reduce rate of oxygen uptake by water, retards light intensity by 90%
- Arsenic causes black foot disease; asbestos causes asbestosis, Beryllium causes Berylliosis and Cadmium causes Itai-Itai disease.

Insecticides and Pesticides



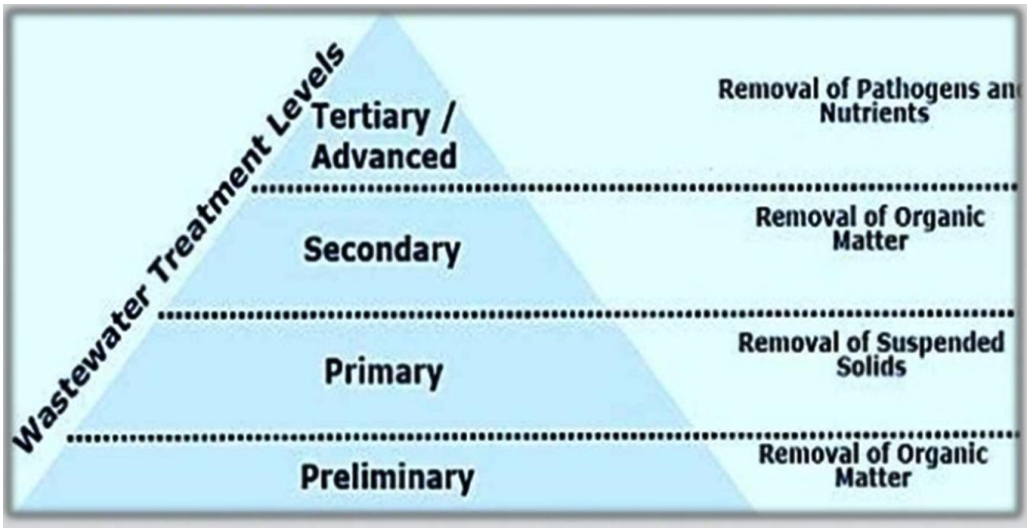
- These are biologically active chemicals used for pest control. They include DDT (Dichloro Diphenyl Trichloroethane), aldrin etc.
- Increased accumulation of these substances in food chain at high trophic level is called **biological magnification**.

Control measures and prevention of water pollution

- Following strategies are adopted for controlling water pollution:
  - Two approaches are used: **input control** and **output control**. Input control means 'reducing generation of pollutants' while output control means 'controlling pollutants after being produced'.
  - Output control further involves two strategies: volume reduction and strength reduction. Volume reduction means reducing total volume of pollutant while strength reduction means reducing harmful effects of pollutants.
  - Both, volume and strength of the polluted water can be reduced by different types of water treatment plants (WTP). This includes **Sewage Treatment Plants (STP)** and **Effluent Treatment Plants (ETP).**
  - In these treatment plants, pollutants are removed through sequential steps that include: **Primary treatment**, **Secondary treatment** and **Tertiary treatment.**
  - In **Primary treatment** bigger impurities are removed using physical processes (sedimentation, filtering, decanting).
  - In **Secondary treatment** organic compound are oxidized by biological oxidation (in presence of bacteria).
  - In **Tertiary treatment**, the remaining impurities are oxidized by chemical oxidants and disinfection is done by UV-rays, ozone etc.

Waste water Treatment

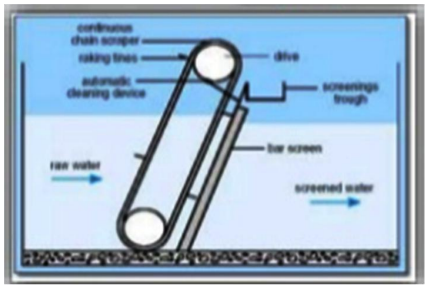
Waste water treatment process can be conveniently classified as below:

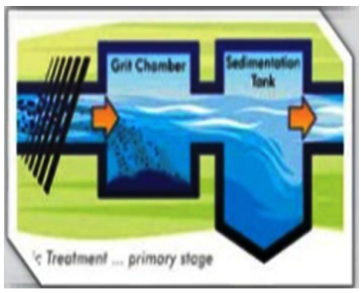


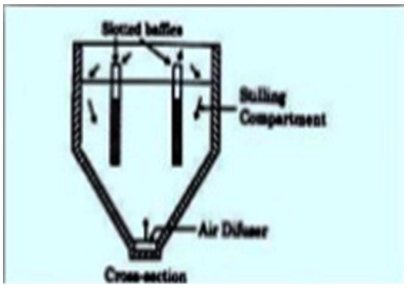
Preliminary Treatment

It involves the removal of floating material, settleable inorganic solids and greasy materials.

- **Screeners**- Device with opening and further classified as coarse (75-150mm), medium (20-70mm) and fine (< 20 mm)
- **Shredder**- Special device that cut and retain floating and suspended material
- **Grit Chambers**- Heavy inorganic material can be removed. Based on principle of sedimentation
- **Skimming Tank**- Greasy material can be removed using skimming tank which is divided into 3 compartments.

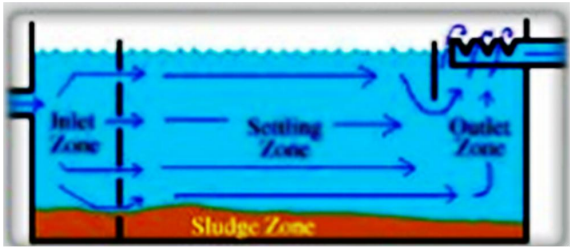


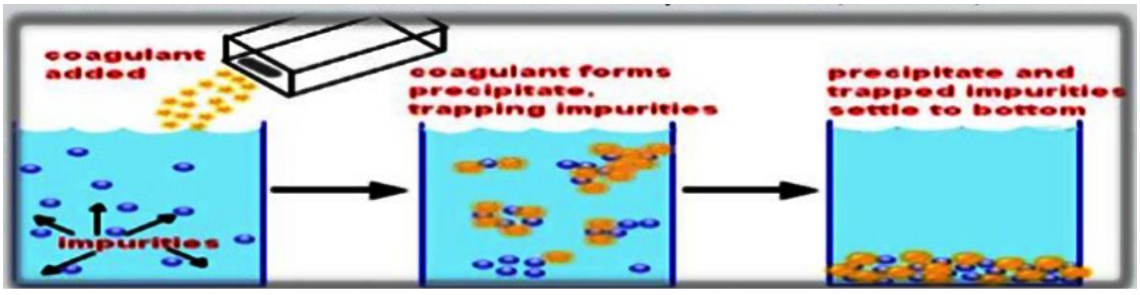




Primary Treatment

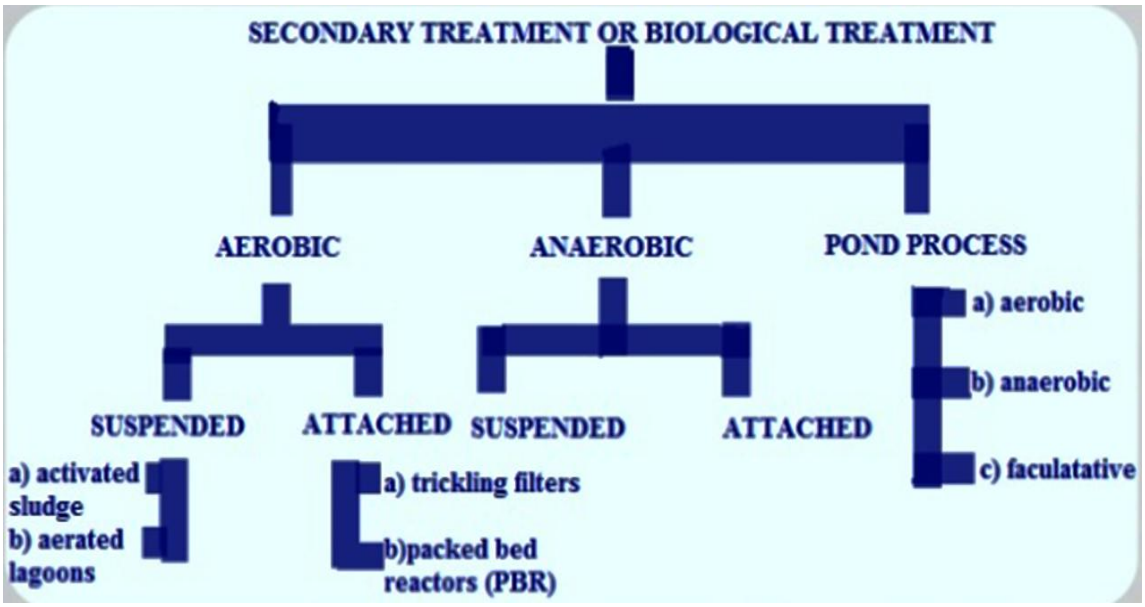
- It is aimed at removal of suspended organic solids that can not be removed in preliminary treatment. It involves the process of sedimentation
- Sedimentation is the separation from water by gravitational settling if suspended particles are heavier than water
- Sedimentation tank have inlet zone, settling zone, outlet zone and sludge zone
- Chemicals are added to aid sedimentation such as: alum, iron salts, lime etc.





Secondary/Biological Treatment

- It is required to remove dissolved and fine colloidal organic matter. This process involves the use of microorganisms that decompose the unstable organic matter to stable inorganic forms.



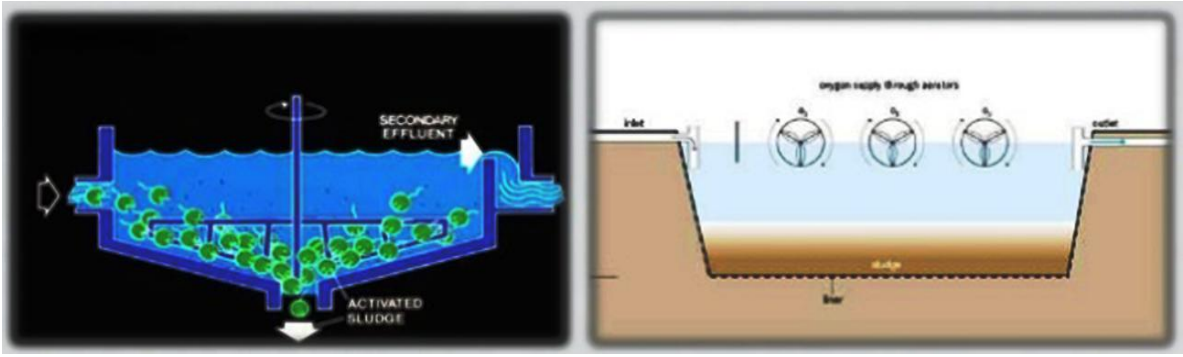
Aerobic Suspended growth Treatment Process

- **Activated sludge process:** The sewage containing organic matter with microorganism is aerated in an aeration tank.

Advantage: Cost-effective, sludge has higher fertilizer value

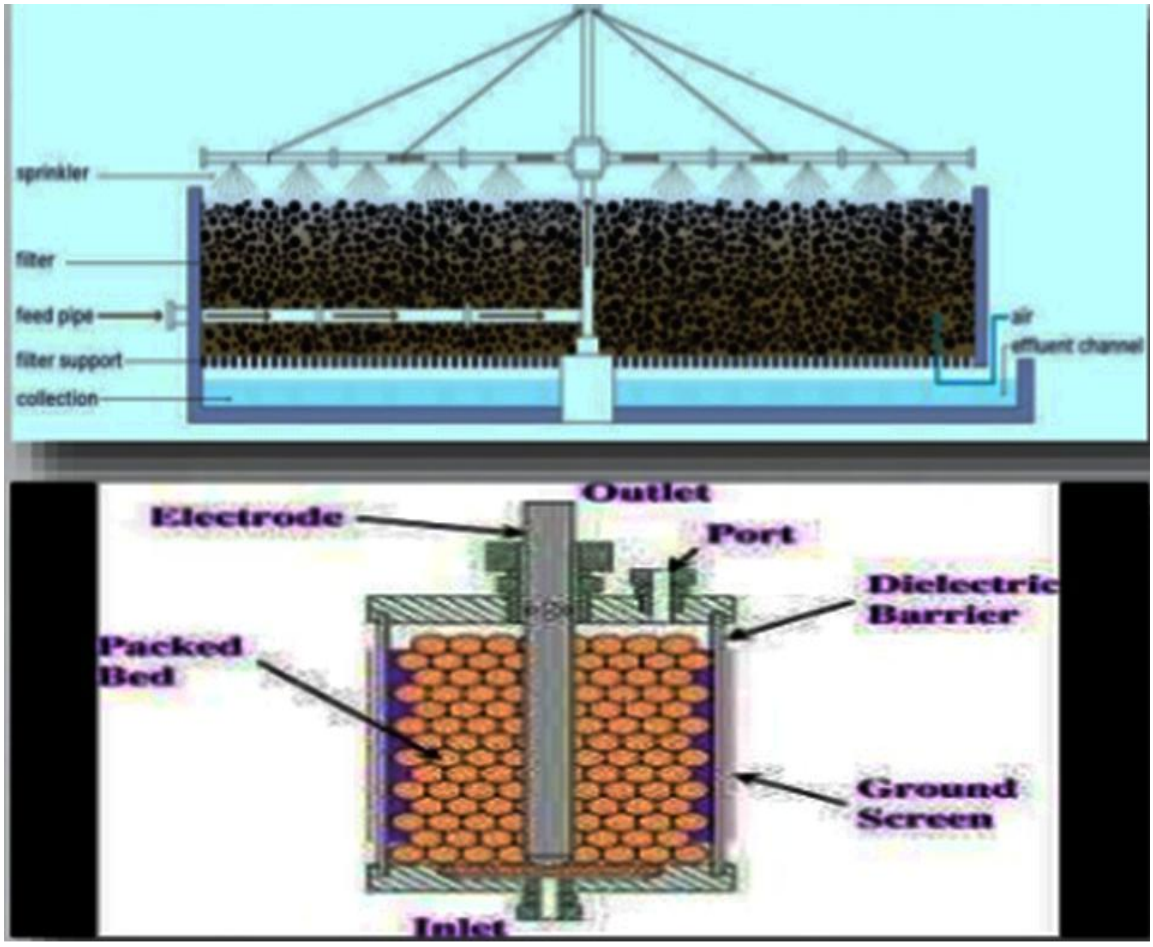
$$\text{Organic Matter} + O_2 \longrightarrow CO_2 + NH_3 + H_2O + \text{New Cells}$$

- **Aerated Lagoon:** They are also known as aerated ponds, are the facultative stabilization ponds where in surface aerators are installed to overcome bad odors.



Aerobic Attached Growth Treatment Process

- **Trickling Filters:** It has a bed of coarse, hard, porous material over which sewage is percolated or trickled and microorganisms attached to medium degrade the organic matter.
- **Packed bed reactors:** A reactor is packed with a medium to which microorganism get attached and form biofilms.

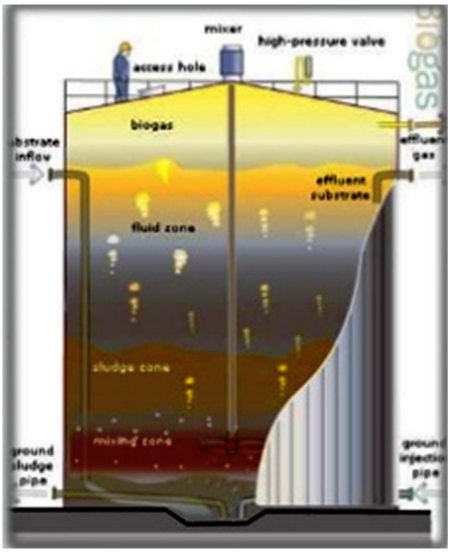


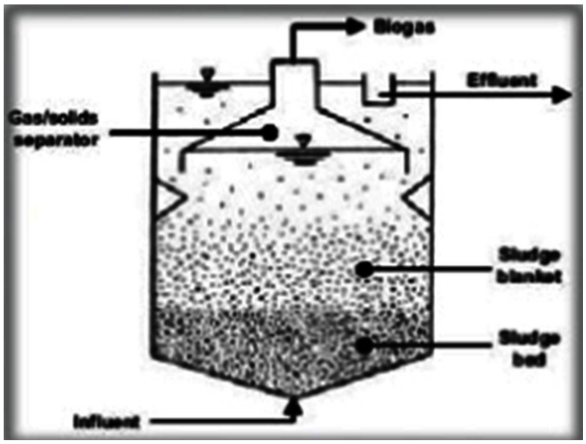
Anaerobic Suspended Growth Treatment Process

- **Anaerobic Digestion:** Process is carried out in a air tight reactor. It involves three stages namely: hydrolysis, acidogenesis (clostridium sp., cornylbacterium), methanogeneis (methanococci, methanobacillus)

Anaerobic Attached Growth Treatment Process

- **Anaerobic Filter Process:** Consist of column fitted with solid media for treatment of organic matter in sewage. Solid media bacterium is retained in the column.



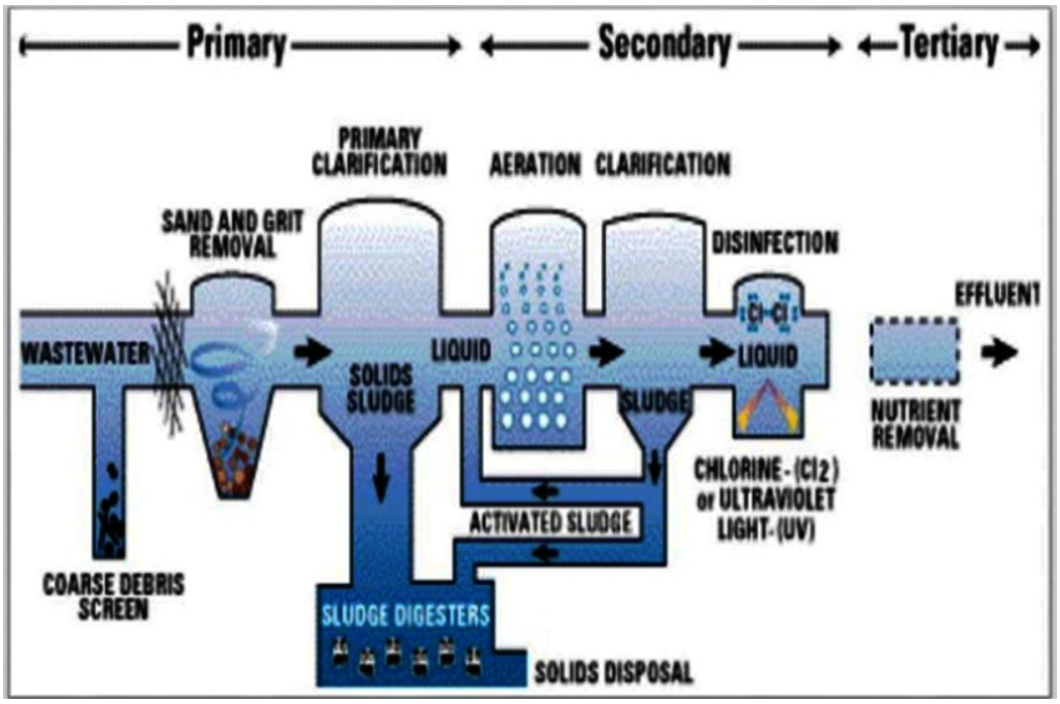


Tertiary Treatment

Only 1-2% domestic sewage receives tertiary treatment which is the most advance phase of sewage treatment. The tertiary treatment is needed under the following circumstances

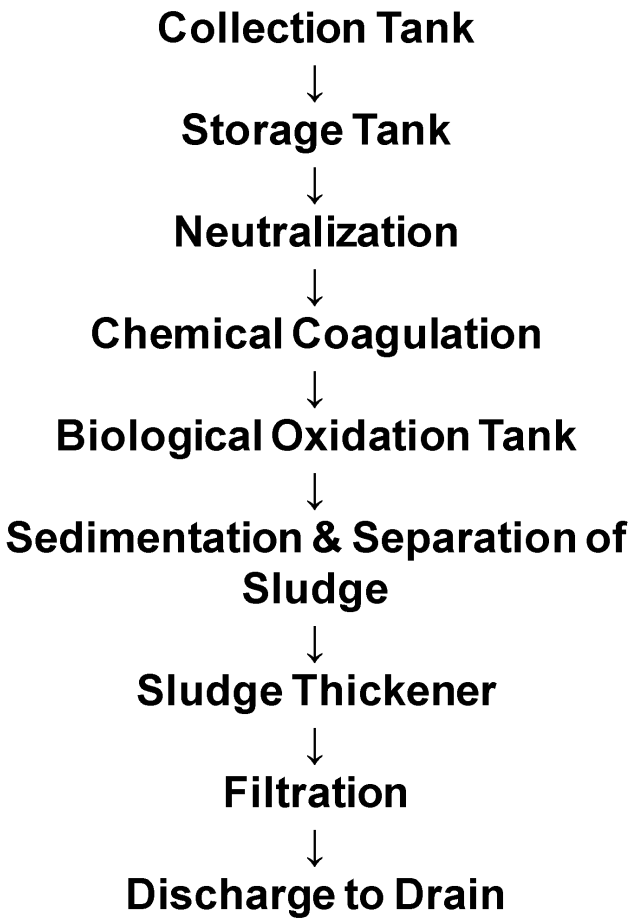
- When the quality of effluent to be discharged does not meet the standard requirement
- When there is necessary to remove dissolved solids by Ion Exchangers
- To remove nitrogen and phosphorus
- To remove pathogenic organisms through disinfection

Water Treatment Processes Summary



Process Flow Chart of Effluent Treatment Plant (ETP)

Industries generate huge amount of liquid waste and industrial effluents. Before releasing these liquids to outwards, the plant which treats this effluent to a harmless form for the environment is known as **Effluent Treatment Plant (ETP)**.



The details of all process are described below:

Collection Tank: Commencing part, wastes from different section enter here.
Storage Tank: Wastewater from the collection tank is properly mixed here using blower pipes.
Neutralization: pH is controlled here.
Chemical Coagulation: Chemical coagulants such as $Fe_2(SO_4)_3$ (Iron sulfate), $Al_2(SO_4)_3$ (Aluminum sulfate) etc. are used for coagulation.
Biological Oxidation Tank: The treatment of wastewater by microorganisms such as algae, fungi, or bacteria under aerobic or anaerobic conditions during which organic matter in wastewater is oxidized or incorporated into cells. Blowing air during the process helps the growth and efficacy of wastewater treatment using microorganisms.

Sedimentation & Separation of Sludge: The sedimentation process allows suspended particles to settle out after the biological oxidation process. A layer of accumulated solids, called **sludge**, forms at the bottom of the tank and is periodically removed.

Sludge Thickener: After exceeding the required level of recycling, sludge passed through thickening chamber. Thickening of sludge increases its solids content and reduces the volume of free water thereby minimizing the unit load on downstream processes such as digestion and dewatering. The most commonly used thickening processes include gravity thickening, dissolved air flotation, and rotary drum thickening.

Filtration: Filtration layer consists of sand and rock bed that filters the remaining sludge from the treated water after the sedimentation process.

Discharge to Drain: Release of the treated wastewater to environment with the check of final load of effluent in it.

Besides it, there are certain common measures to control pollution like:

- Domestic and industrial waste waters should be discharged into rivers only after proper treatment through sewage treatment plants (STPs) and ETPs.
- Solid wastes must not be mixed with liquid wastes and should not be thrown into to water bodies. They should be separately managed.
- Sources of drinking water should be protected from pollution. Polluting activities (e.g., industrial use, discharging effluents, bathing, washing, cattle rearing etc.) must be avoided in vicinity of source of drinking water.
- Water bodies should be regularly cleaned of aquatic weeds, plants and other crude impurities like polythene, metals, garbage etc. Special breeds of fish, which feed on mosquito eggs and bacteria, can be cultured in water bodies.
- Afforestation must be done for reducing soil erosion and improving local soil hydrology. Use of agrochemicals need to be minimized.
- Public awareness regarding water pollution and its control measures should be created.

Noise Pollution

Contents

Noise

Introduction

- It is an unpleasant and disturbing sound, which is found to be responsible for several auditory and no-auditory adverse effects on human health and well-being, ranging from simple annoyance to hearing loss.
- The rapid growth of urbanization, industrialization, construction works, increased number of vehicles and deforestation is the major cause of air and noise pollution.
- According to WHO, Noise is considered as a major concerned environmental factor for an unhealthy society (WHO, 2011)
- Noise is a perpetual, significant contributor to occupational diseases in numerous working environments.
- Noise health effects depend on the combination of intensity, frequency and duration of exposure to noise.

Sources of Noise Pollution

- Industries
- Rail and air traffic
- Road Traffic
- Construction
- Indoor Sources (TV, Mixer, Fridge etc.)
- Loud Speakers
- Fire Crackers

Impact on health due to noise pollution

Pathological Effects	Physiological Effects	Psychological Effects
Hearing loss, reduction of speech intelligibility, acoustic traumas, auditory fatigue, etc.	Changes in blood pressure, pulse rate, constriction of blood vessels, dilation of the pupil of eye and changes in blood cholesterol content, etc.	Feelings of discomfort, sleep interference, reduced intellectual performance, fatigue, vexation, irritation, distress, mental or neurological disorders, antisocial behaviour, etc.

Noise above 60dB has a negative effect on increased use of psychotropic medication

Properties of Sound

- Physically, Sound is a mechanical disturbance propagated as a wave motion in air and other elastic and mechanical media such as water or, steel.
- Physiologically, Sound is an auditory sensation evoked by this physical phenomenon.(not all sound wave evoke an auditory sensation, e.g., the frequency of ultrasound is too high to excite the sensation of hearing)
- Sound waves involve a succession of compressions and rarefactions of an elastic medium such as air.
- These waves are characterized by the amplitude of pressure changes, their frequency and the velocity of propagation.

Wavelength=speed of Sound/ frequency.

Speed of sound in air(20°C)=344 m/s.
Sound travels much faster in solids than in air.
(wood=3,962 m/s, Steel=5,029 m/s)

frequency

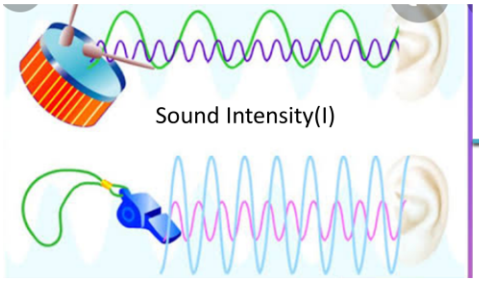
Number of compressions and rarefactions per unit time (sec)

unit=hertz(Hz)

Sound Power

Rate at which energy is transmitted by a sound wave

Represented in terms of watt.
Watt=Joules/Sec



Average sound power per unit area in the direction of propagation of sound wave.
I=W/A (watt/m^2)

For a Vibrating Sphere, $I=W/4\pi r^2$

When Noise is far away from the source,
$I=P^2/\ell e$
P=Sound Pressure
ℓ=Density of the medium i.e., air=1.185
e=speed of Sound i.e.,340m/sec.

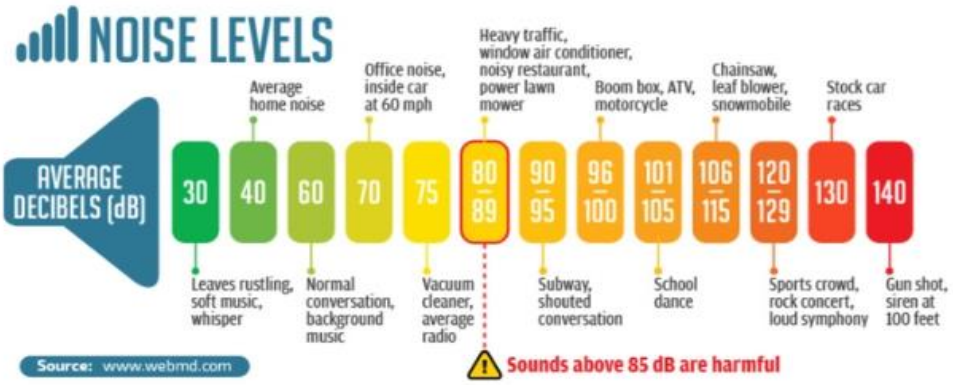
Decibel

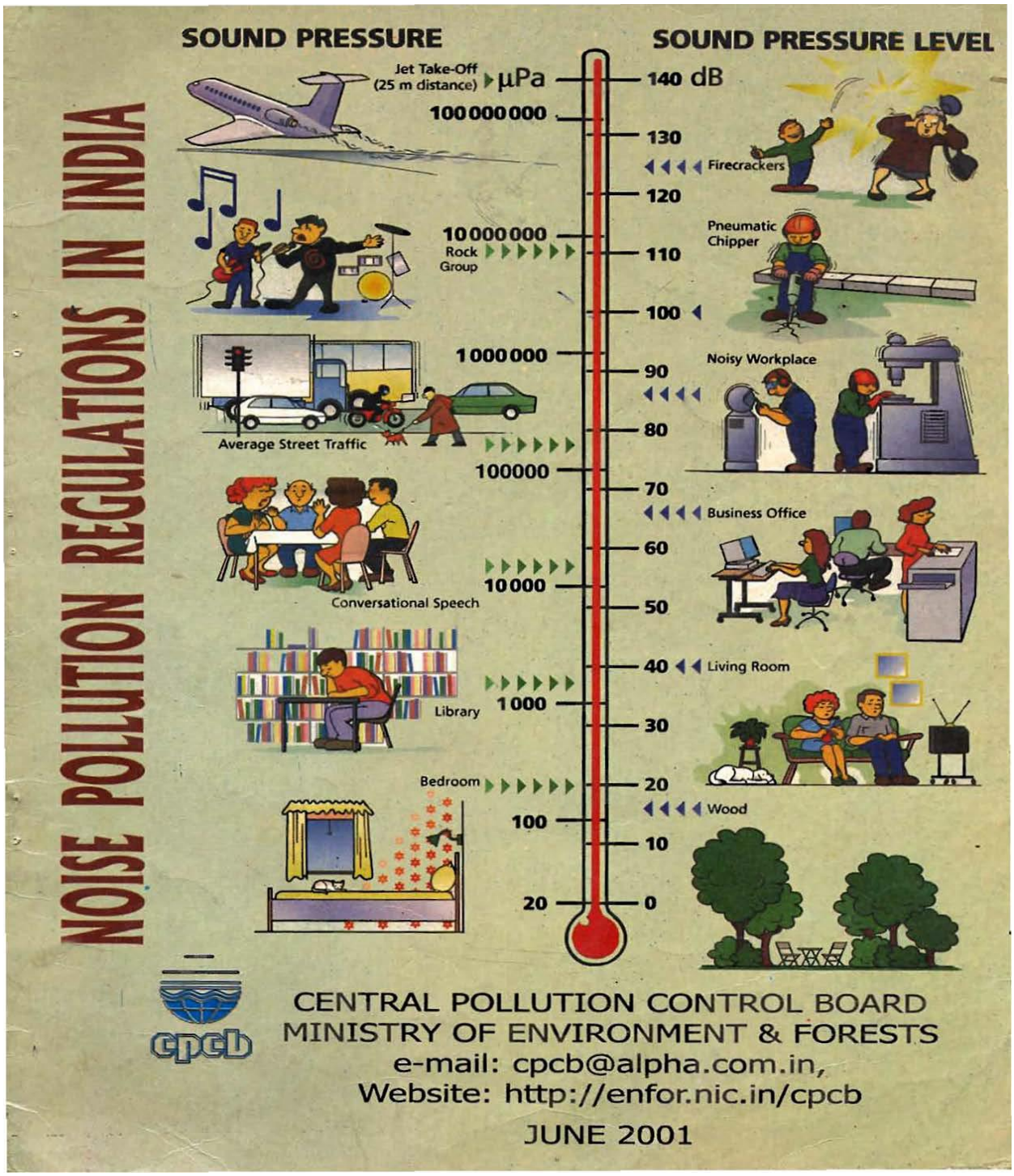
- A scale ten times the logarithm of the ratio of a measured quantity to specified reference quantity.
- It represents sound level.

  Sound power level, $L_w = 10\log_{10}(W/W_o)$

  W = measured Sound power

  W_o = Reference sound power (10^{-12} W)




NOISE POLLUTION REGULATIONS IN INDIA
SOUND PRESSURE
SOUND PRESSURE LEVEL
Jet Take-Off (25 m distance)
µPa
140 dB
100000000
130
Firecrackers
120
10000000
Rock Group
110
Pneumatic Chipper
100
1000000
90
Noisy Workplace
Average Street Traffic
80
100000
70
Business Office
60
10000
Conversational Speech
50
40
Living Room
1000
Library
30
Bedroom
20
Wood
100
10
20
0
CENTRAL POLLUTION CONTROL BOARD
MINISTRY OF ENVIRONMENT & FORESTS
e-mail: cpcb@alpha.com.in,
Website: http://enfor.nic.in/cpcb
JUNE 2001

Problems

1. The sound power generated from a moving tractor is 0.001 watt. What is the Sound Power Level?

Ans-

As we know, $Lw=10\log10\ (w/w_0)$

$=10\log\ (0.001/10^{-12})$

$=90$ dB

2. If a sound source has a pressure of 2000µp at 10m distance. Configure the sound pressure level in dB?

- Sound Intensity in watt/m².

- Sound Power in watt.

Ans-
As we know, $Lp(dB)=10\log_{10}(P/P_r)^2$
$=10\log\ (2000/20)^2$
$=40$dB
ii. As we know, $I=P^2/\ell e$
$=(2000x10^{-6})^2/(1.185x340m/s)$
$=9.9x10^{-9}$ watt/m².
iii. Given, r=10m
Here measured sound power is not given.
So, $I= W/4\pi r^2$

$\Rightarrow 9.9x10^{-9}=W/4x3.14x100$
$\Rightarrow W= 1.24x10^{-5}watt$
So, $Lw=10\log_{10}(w/w_0)$
$=>Lw=10\log\ ((1.24x10^{-5})/10^{-12})$
$=>Lw=71watt$

3. Determine the sound power level from combining the four sound levels of 56, 68, 71 and 48 dB.

- $L_W=10\ log_{10}\ (W/W_0)$; $W= W_0x10^{L_W/10}$
- $W_1= W_0x\ 10^{5.6}$
- $W_2 = W_0x\ 10^{6.8}$
- $W_3 = W_0x\ 10^{7.1}$
- $W_4 = W_0x\ 10^{4.8}$
- Resultant SPL = $10\ [\log\ (10^{5.6}+ 10^{6.8} + 10^{7.1}+ 10^{4.8})\approx 73$ dB

4. If an Industrial fan generates a noise level of 65 dB for 10 minutes out of every hour. Compute the L_{Aeq}, if the background level is 55 dB?

- $L_{Aeq} = 10 \log[\frac{1}{T}(10^{L_1/10} \times T_1 + 10^{L_2/10} \times T_2]$
- $L_{Aeq} = 10 \log[\frac{1}{T}(10^{6.5} \times 10 + 10^{5.5} \times 50]$
- L_{Aeq} = ?

Sound Perception and Measurement

- The magnitude of sound as perceived by human ear is called Loudness.
- Ear is not equally sensitive to all frequencies and amplitudes of sound pressure. For this reason, the sound pressure levels of two different noises may be same. The first may be judged to be louder than the second. If the sound energy of the first is concentrated in a

frequency region where the ear is more sensitive.

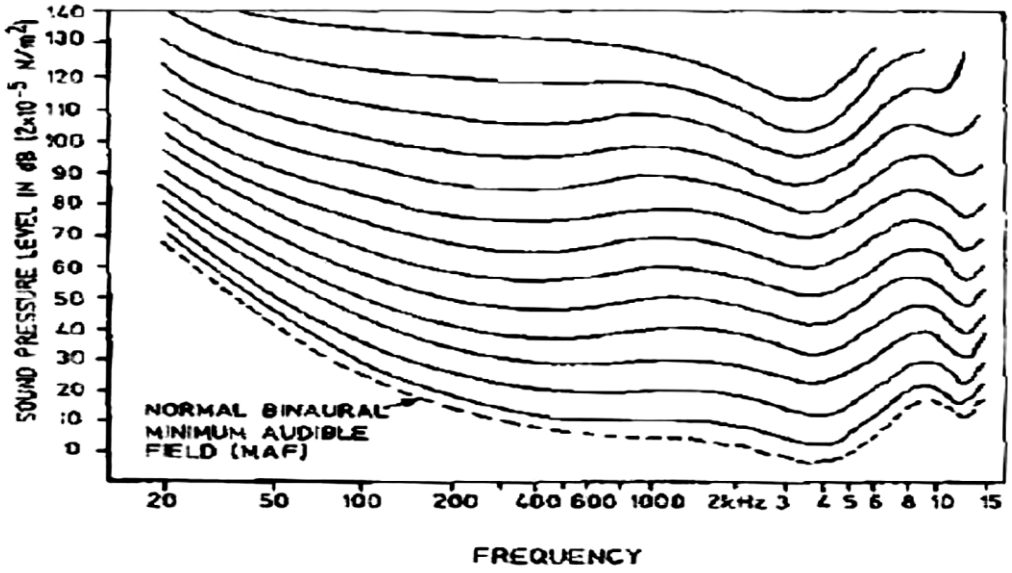


Fig. 1 Equal Loudness Contours for Pure Tones

- The frequency weighting networks are incorporated in sound level meters to obtain sound levels which bear a closer relationship to loudness than the sound pressure levels.
- Generally three types of filters having frequency response curves A,B and C are employed to find out the ear response at low, medium and high loudness
- 'A' filter provides the highest correlation between the physical measurement and subjective evaluations of loudness of noise. So, it is internationally accepted and expressed as dB(A).

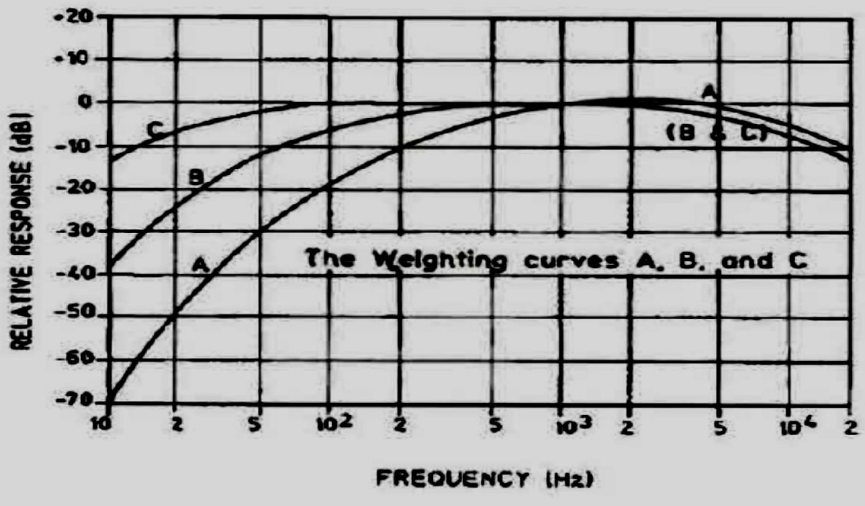


Fig. 2 Frequency- weighting Network for Sound Level Meters

Equivalent Continues Noise Level

Equivalent continues noise level (L_{Aeq}) of that steady sound which over the same interval of time contains the same total energy as the fluctuating sound.

$\mathrm{LAeq} = 10\log_{10}(\frac{1}{T}\sum_{i=1}^{n} 10^{0.1li} \times t_i)$

Where, T=Total time of operation.

L_i=Noise level of the ith sample.

T_i=Fraction of total time.

N=number of sample.

Sound pressure level (Lp)

Sound is measured with a Sound level meter which is usually a portable self contained instrument incorporating a microphone amplifier, a voltmeter and a attenuator. The whole of which is calibrated to read sound pressure level directly.

Sound pressure level, $Lp(dB)=10\log10\ (P/P_r)^2$.....(i)

P=measured Sound Pressure

P_r =Reference sound Pressure (20µp)

Average sound pressure levels

$\overline{Lp} = 20log\frac{1}{N}\sum_{j=1}^{N} 10^{(\frac{Lj}{20})}$.....(ii)

$\overline{Lp}$=Average Sound Pressure Level

L_j=The jth sound pressure level.

J=1,2,3.....N

Physical conditions for Noise measurement

- Noise measurement should be done at location of maximum noise.
- Maximum wind speed should be 5m/sec
- Humidity up to 90%

- Temp 10-50°C

Problem

1. If an Industrial fan generates a noise level of 65 dB (A) for 10 minutes out of every hour. Compute the LAeq, if the background level is 55dB (A)?

Ans-$L_{Aeq}=10\log_{10}(\frac{1}{T}\sum_{i=1}^{n}10^{0.1li}\times t_i)$

Here, T=60,L1=65 dB(A) and L2=55dB(A) t1=10, t2=50

So, $L_{Aeq}=10log\ [\frac{1}{60}(10^{0.1\times65}\times10)+(10^{0.1\times55}\times50)$

= 59dB(A)

Ambient Air quality standards in respect of Noise

Area Code	Category of Area/Zone	Limits of dB(A) Leq	
		Day Time	**Night Time**
A	**Industrial Area**	75	70
B	**Commercial Area**	65	55
C	**Residential Area**	55	45
D	**Silence Zone**	50	40

- Day time shall mean from 6:00 AM to 10:00 PM.
- Night time shall mean from 10.00 PM to 6:00 AM.
- Silence Zone is an area comprising not less than 100 meters around hospitals, educational institutions, and Courts Religious places or, any other area which is declared as such by the competent authority.

Permissible Noise level standards for house appliances

Home Appliances	Permissible Noise Level
Refrigerator	60dB(A)
Air Conditioner	68dB (A)
Mixer	75dB(A)
Generator	85-90dB(A)

Control of Noise

Noise Reduction at the Source

- The reduction of the exciting forces e.g., reduction of impacts or, impulsive forces, balancing of moving masses, reduction of frictional forces by proper alignment and lubrication etc.
- Reduction of the response of various components of the system of these exciting forces e.g., by application of vibration dumping materials to the radiating surfaces.
- Changes in operating procedure, e.g., a factory, adjacent to the residential areas, suspend or reduce noise generating operations at night.

Noise control of the transmission path

- Sitting e.g., increasing distance between source and the Receiver.
- Path deflection e.g., by use of barrier.
- Properly designed enclosures.
- Absorption e.g., use of sound absorbing material in a room where both the source and the receiver are present in a room.

Protective Measures at the receiver

- Use of personal protective equipment, e.g., use of earplugs, earmuffs, noise helmets etc.
- Education and public relations.
- Exposure Control. e.g., the rotation of personnel so that work assignments in the intense noise area is for a limited period of time only.

Marine Pollution

Introduction

Oceans are the largest water bodies on the planet Earth. Over the last few decades, excessive human activities have severely affected marine life on the Earth's oceans.

Ocean pollution, also known as **marine pollution**, is the spreading of harmful substances such as oil, plastic, industrial and agricultural waste and chemical particles into the ocean.

Marine pollution is a combination of chemicals and trash, most of which comes from land sources and is washed or blown into the ocean.

This pollution results in damage to the environment, to the health of all organisms, and to economic structures worldwide.

Marine pollution is a growing problem in today's world. Our ocean is being flooded with two main types of pollution: **chemicals** and **trash**

i. Chemical contamination, or nutrient pollution, is concerning for health, environmental, and economic reasons.

This type of pollution occurs when human activities, notably the use of fertilizer on farms, lead to the runoff of chemicals into waterways that ultimately flow into the ocean.

The increased concentration of chemicals, such as nitrogen and phosphorus, in the coastal ocean promotes the growth of algal blooms, which can be toxic to wildlife and harmful to humans.

ii. Marine trash encompasses all manufactured products—most of them plastic that end up in the ocean. Littering, storm winds, and poor waste management all contribute to the accumulation of this debris, 80 percent of which comes from sources on land.

Various causes of marine pollution:

Since oceans provide the home to a wide variety of marine animals and plants, it is the responsibility of every citizen to play his or her part in making these oceans clean so that marine species can thrive for a longer period of time.

There are various ways in which pollution enters the ocean/marine system. Some of them are:

i.. Direct discharge

Pollution can enter the ocean directly. Sewage or polluting substances flow through sewage, rivers, or drainages directly into the ocean.

This is often how minerals and substances from mining camps find their way into the ocean.

The release of other chemical nutrients into the ocean's ecosystem leads to reductions in oxygen levels, the decay of plant life, and a severe decline in the quality of the seawater itself.

As a result, all levels of oceanic life, plants and animals, are highly affected.

ii. Toxic chemicals from industries

Industrial and agricultural waste is another most common form of wastes that is directly discharged into the oceans, resulting in ocean pollution.

The dumping of toxic liquids in the ocean directly affects marine life as they are considered hazardous, and secondly, they raise the temperature of the ocean, a phenomenon known as thermal pollution, as the temperature of these liquids is quite high.

Animals and plants that cannot survive at higher temperatures eventually perish.

iii. Land Runoff

Land runoff is another source of pollution in the ocean. This occurs when water infiltrates the soil to its maximum extent, and the excess water from rain, flooding or melting flows over the land and into the ocean.

Often, this water picks up man-made, harmful contaminants that pollute the ocean, including fertilizers, petroleum, pesticides and other forms of soil contaminants.

Fertilizers and waste from land animals and humans can be hugely detrimental to the ocean by creating dead zones.

iv. Large scale oil Spills or ship pollution

Ship pollution is a huge source of ocean pollution, the most devastating effect of which is oil spills.

Crude oil lasts for years in the sea and is extremely toxic to marine life, often suffocating marine animals to death once it entraps them.

Crude oil is also extremely difficult to clean up, unfortunately, meaning that when it is split, it is usually there to stay.

Besides, many ships lose thousands of crates each year due to storms, emergencies, and accidents.

This causes noise pollution (excessive, unexpected noise that interrupts the balance of life, most often caused by modes of transportation), excessive algae, and ballast water.

v. Ocean mining

Ocean mining sites drilling for silver, gold, copper, cobalt, and zinc create sulphide deposits up to three and a half thousand meters down into the ocean.

While we yet to have the gathering of scientific evidence to fully explain the harsh environmental impacts of deep-sea mining, we do have a general idea that deep sea mining causes damage to the lowest levels of the ocean and increases the toxicity of the region.

This permanent damage dealt also causes leaking, corrosion and oil spills that only drastically further hinder the ecosystem of the region.

vi. Littering

Pollution from the atmosphere occurs when far inland objects are blown by the wind over long distances and end up in the ocean.

These objects can be anything from natural things like dust and sand to man-made objects such as debris and trash. Most debris, especially plastic debris, cannot decompose and remains suspended in the ocean's current for years.

Animals can become snagged on the plastic or mistake it for food, slowly killing them over a long period of time. Animals who are most often the victims of plastic debris include turtles, dolphins, fish, sharks, crabs, sea birds, and crocodiles.

Also, the temperature of the ocean is highly affected by carbon dioxide and climate changes, which primarily impacts the ecosystems and fish communities that live in the ocean. In particular, the rising levels of CO_2 acidify the ocean in the form of acid rain.

Even though the ocean can absorb carbon dioxide that originates from the atmosphere, the carbon dioxide levels are steadily increasing, and the ocean's absorbing mechanisms, due to the rising of the ocean's temperatures, are unable to keep up with the pace.

Effects of Marine pollution:

i. Effect of Toxic Wastes on Marine Animals

The oil spill is dangerous to marine life in several ways.

The oil spilled in the ocean could get on to the gills and feathers of marine animals, which makes it difficult for them to move or fly properly or feed their children.

The long term effect on marine life can include cancer, failure in the reproductive system, behavioural changes, and even death.

ii. Disruption to the cycle of coral Reefs

Oil spill floats on the surface of the water and prevents sunlight from reaching to marine plants and affects the process of photosynthesis.

Skin irritation, eye irritation, lung and liver problems can impact marine life over a long period of time.

iii. Depletes Oxygen content in water

Most of the debris in the ocean does not decompose and remain in the ocean for years.It uses oxygen as it degrades. As a result of this, oxygen levels go down.

When oxygen levels go down, the chances of survival of marine animals like whales, turtles, sharks, dolphins, penguins for a long time also goes down.

iv. Failure in the reproductive system of Sea Animals

Industrial and agricultural wastes include various poisonous chemicals that are considered hazardous for marine life.

Chemicals from pesticides can accumulate in the fatty tissue of animals, leading to failure in their reproductive system.

v. Effect on food chain

Chemicals used in industries and agriculture get washed into the rivers and from there are carried into the oceans.

These chemicals do not get dissolved and sink at the bottom of the ocean.

Small animals ingest these chemicals and are later eaten by large animals, which then affects the whole food chain.

vi. Affects Human Health

Animals from impacted food chain are then eaten by humans, which affects their health as toxins from these contaminated animals get deposited in the tissues of people and can lead to cancer, birth defects or long term health problems.

How to control Marine pollution?

Marine or Ocean pollution is a raging problem that needs to be solved as early as possible.

With the world's oceans getting polluted, the marine ecosystems are getting severely disturbed.

Not only that, but the world's water reserves are also becoming more and more limited.

In these situations, it is essential that we find ways of solving ocean pollution.

Some of the ways are as follows:

i. Reducing the use of Plastic Products

Plastic wastes form the largest portion of ocean pollutants. Out of the 260 million tons of plastic produced each year globally, approximately 10% ends up in the oceans.

These plastics then take thousands of years to decompose, during which time it possess a terrible threat to life in the oceans.

Thus, reduction in the use of plastic products could help in significantly reducing the rates of ocean pollution.

ii. Use Reusable Bottles and Cutlery

Use and throw bottles and cutlery, too, are an immense contributor to ocean pollution.

We must not forget that most of the non-reusable bottles and cutlery are made out of either plastic or Styrofoam.

Both these materials require a few hundred or thousand years to decompose.

A plastic bottle would require about 450 years to decompose completely. In the meanwhile, it would remain inside the ocean, releasing toxins that would poison the marine life.

iii. Recycle Whatever You Can

The 3 R's (Reduce, Reuse, Recycle) are definitely the savior of ocean health. With the increase in population, it is true that the waste produced would also increase significantly.

As finding dumping grounds become more and more difficult, a lot of the wastes find their way to the ocean beds. These wastes that are dumped in the ocean remain there for a long time, affecting marine life.

One of the useful ways to reduce waste production is recycling. Before throwing things away, we could check if something is recyclable. Then the products that can be recycled can be taken to the recycling centre nearby.

iv. Stop Littering the Beach, and Start Cleaning It

The beach is undoubtedly one of the loveliest places to visit and hang out in. As a result of this, there is a lot of littering around as well. The first and foremost thing that really needs to stop is this.

Abundant dustbins should be placed on the beaches.

If someone is seen littering, they must be stopped immediately, and certain strict rules and regulations must be followed at all times.

Also, if the beach seems untidy, we could pick up the wastes and throw it in the dustbin.

v. Reducing the Use of Chemical Fertilizers

Runoffs, too, pollute the oceans immensely.

To prevent this, the use of chemical fertilizers must also be controlled and regulated. It must be remembered that excess use of chemical fertilizers harms not only the soil but also the water bodies nearby and, ultimately, the ocean. These runoffs are so toxic that they can very easily kill marine life.

vi. Reducing the Energy Use

As the population increases, our demand for energy increases too.

A major chunk of this energy is produced from petroleum. This petroleum is obtained by the drilling of the ocean beds. Any spillage during the procedure could harm marine life.
Not only that, but the procedure itself also violates the marine ecological balance.

So, by controlling our energy use, we could also solve the problem of ocean pollution