PT Revision Notes for Basics – Civils360

Part 2 – Ecology and Environment

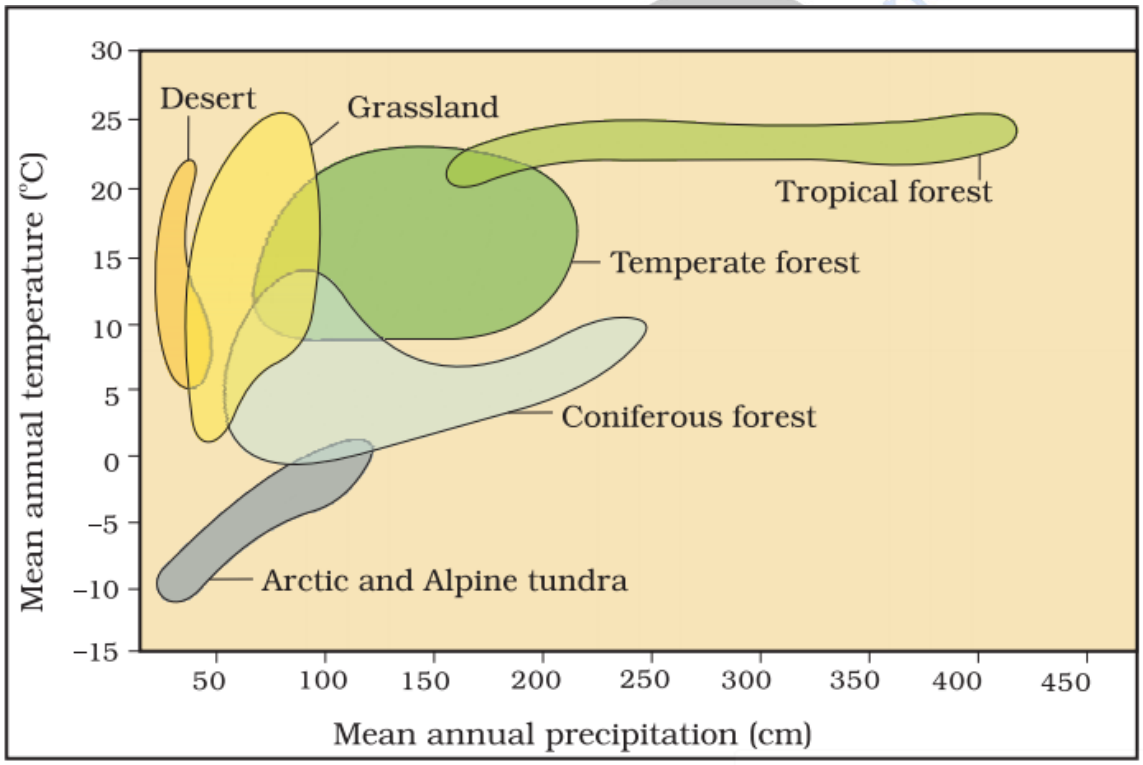
Ecology and Environment PT Revision Notes

ORGANISMS AND POPULATIONS

- **ORGANISM AND ITS ENVIRONMENT**
  - the rotation of our planet around the Sun and the tilt of its axis cause annual variations in the intensity and duration of temperature, resulting in distinct seasons
  - Regional and local variations within each biome lead to the formation of a wide variety of habitats.
  - key elements that lead to so much variation in the physical and chemical conditions of different habitats
    - temperature, water , light , soil.
- **Major Abiotic Factors**
- **Temperature:**
  - Temperature is the most ecologically relevant environmental factor
  - the average temperature on land varies seasonally, decreases progressively from the equator towards the poles and from plains to the mountain tops.
  - There are, however, unique habitats such as thermal springs and deep-sea hydrothermal vents where average temperatures exceed 1000 C.
  - A few organisms can tolerate and thrive in a wide range of temperatures (they are called **eurythermal**), but, a vast majority of them are restricted to a narrow range of temperatures (such organisms are called **stenothermal**)
- **Water:**
  - For aquatic organisms the quality (chemical composition, pH) of water becomes important.
  - The salt concentration (measured as salinity in parts per thousand), is less than 5 per cent in inland waters, 30-35 per cent the sea and > 100 per cent in some hypersaline lagoons
  - Some organisms are tolerant of a wide range of salinities (euryhaline) but others are restricted to a narrow range (stenohaline).
- **Light:**
  - Many plants are also dependent on sunlight to meet their photoperiodic requirement for flowering. For many animals too, light is important in that they use the diurnal and seasonal variations in light intensity and duration (photoperiod) as cues for timing their foraging, reproductive and migratory activities.

- The UV component of the spectrum is harmful to many organisms while not all the colour components of the visible spectrum are available for marine plants living at different depths of the ocean

- **Soil:**
  - The nature and properties of soil in different places vary; it is dependent on the climate, the weathering process, whether soil is transported or sedimentary and how soil development occurred.
  - the organism should try to maintain the constancy of its internal environment (a process called homeostasis) despite varying external environmental conditions that tend to upset its homeostasis.
- Distribution of Biomes



e 13.1 Biome distribution with respect to annual temperature and precipitation

- **Regulate:** Some organisms are able to maintain homeostasis by physiological (sometimes behavioural also) means which ensures constant body temperature, constant osmotic concentration, etc. All birds and mammals, and a very few lower vertebrate and invertebrate species are indeed capable of such regulation (thermoregulation and osmoregulation)
  - **'success' of mammals is largely due to their ability to maintain a constant body temperature and thrive whether they live in Antarctica or in the Sahara desert**

- **Plants, on the other hand, do not have such mechanisms to maintain internal temperatures**
- **Conform:** An overwhelming majority (99 per cent) of animals and nearly all plants cannot maintain a constant internal environment.
    - In aquatic animals, the osmotic concentration of the body fluids change with that of the ambient water osmotic concentration.
    - These animals and plants are simply conformers
- **Thermoregulation** is energetically expensive for many organisms. This is particularly true for small animals like shrews and humming birds. Heat loss or heat gain is a function of surface area. Since small animals have a larger surface area relative to their volume, they tend to lose body heat very fast when it is cold outside; then they have to expend much energy to generate body heat through metabolism. This is the main reason why very small animals are rarely found in polar regions.
- **Migrate :** The organism can move away temporarily from the stressful habitat to a more hospitable area and return when stressful period is over
- Every winter the famous **Keolado National Park (Bhartpur) in Rajasthan** host thousands of migratory birds coming from Siberia and other extremely cold northern regions
- **Suspend:** In bacteria, fungi and lower plants, various kinds of thickwalled spores are formed which help them to survive unfavourable conditions – these germinate on availability of suitable environment
- In animals, the organism, if unable to migrate, might avoid the stress by escaping in time. The familiar case of bears going into hibernation during winter is an example of escape in time. Some snails and fish go into **aestivation** to avoid summer–related problems-heat and desiccation
- Under unfavourable conditions many zooplankton species in lakes and ponds are known to enter **diapause,** a stage of suspended development.
- **Adaptations**
    - Many desert plants have a thick cuticle on their leaf surfaces and have their stomata arranged in deep pits to minimise water loss through transpiration.
    - They also have a special photosynthetic pathway (CAM) that enables their stomata to remain closed during day time.
    - Some desert plants like Opuntia, have no leaves – they are reduced to spines–and the photosynthetic function is taken over by the flattened stems
    - Mammals from colder climates generally have shorter ears and limbs to minimise heat loss. (This is called the Allen's Rule.) In the polar seas aquatic mammals like seals have a thick layer of fat (blubber) below their skin that acts as an insulator and reduces loss of body heat.
    - Some organisms possess adaptations that are physiological which allow them to respond quickly to a stressful situation.

- **Example:** If you had ever been to any high altitude place (>3,500m Rohtang Pass near Manali and Mansarovar, in China occupied Tibet) you must have experienced what is called altitude sickness. Its symptoms include nausea, fatigue and heart palpitations. This is because in the low atmospheric pressure of high altitudes, the body does not get enough oxygen. But, gradually you get acclimatised and stop experiencing altitude sickness. How did your body solve this problem? The body compensates low oxygen availability by increasing red blood cell production, decreasing the binding capacity of hemoglobin and by increasing breathing rate.
- Desert lizards lack the physiological ability that mammals have to deal with the high temperatures of their habitat, but manage to keep their body temperature fairly constant by behavioural means. They bask in the sun and absorb heat when their body temperature drops below the comfort zone, but move into shade when the ambient temperature starts increasing.
- **POPULATIONS**
- **Population Attributes**
    - In nature, we rarely find isolated, single individuals of any species; majority of them live in groups in a well defined geographical area, share or compete for similar resources, potentially interbreed and thus constitute a population
    - Both the species benefit in **mutualism** and both lose in **competition** in their interactions with each other. In both **parasitism and Predation** only one species benefits (parasite and predator, respectively) and the interaction
    - interaction where one species is benefitted and the other is neither benefitted nor harmed is called **commensalism**
    - In **amensalism** on the other hand one species is harmed whereas the other is unaffected.
- Besides acting as 'conduits' for energy transfer across trophic levels, **predators play other important roles. They keep prey populations under control. But for predators, prey species could achieve very high population densities and cause ecosystem instability**.
- Biological control methods adopted in agricultural pest control are based on the ability of the predator to regulate prey population
- The Monarch butterfly is highly distasteful to its predator (bird) because of a special chemical present in its body. Interestingly, the butterfly acquires this chemical during its caterpillar stage by feeding on a poisonous weed
- **Competition:**
    - Firstly, totally unrelated species could also compete for the same resource. For instance, in some shallow South American lakes visiting flamingoes and resident fishes compete for their common food, the zooplankton in the lake.
    - Secondly, resources need not be limiting for competition to occur; in interference competition, the feeding efficiency of one species might be reduced due to the

interfering and inhibitory presence of the other species, even if resources (food and space) are abundant.

- **Parasitism**
  - parasitic mode of life ensures free lodging and meals,
  - Many parasites have evolved to be host-specific (they can parasitise only a single species of host) in such a way that both host and the parasite tend to co-evolve;
  - The human liver fluke (a trematode parasite) depends on two intermediate hosts (a snail and a fish) to complete its life cycle.
    - Parasites that feed on the external surface of the host organism are called ectoparasites
  - Cuscuta, a parasitic plant that is commonly found growing on hedge plants, has lost its chlorophyll and leaves in the course of evolution. It derives its nutrition from the host plant which it parasitises.
  - In contrast, endoparasites are those that live inside the host body at different sites (liver, kidney, lungs, red blood cells, etc.). The life cycles of endoparasites are more complex because of their extreme specialisation.
  - Brood parasitism in birds is a fascinating example of parasitism in which the parasitic bird lays its eggs in the nest of its host and lets the host incubate them.
- **Commensalism:**
  - This is the interaction in which one species benefits and the other is neither harmed nor benefited
  - An orchid growing as an epiphyte on a mango branch, and barnacles growing on the back of a whale benefit while neither the mango tree nor the whale derives any apparent benefit.
  - cattle egret and grazing cattle in close association, a sight you are most likely to catch if you live in farmed rural areas, is a classic example of commensalism.
  - Another example of commensalism is the interaction between sea anemone that has stinging tentacles and the clown fish that lives among them. The fish gets protection from predators which stay away from the stinging tentacles. The anemone does not appear to derive any benefit by hosting the clown fish.
- **Mutualism**
  - This interaction confers benefits on both the interacting species.
  - Lichens represent an intimate mutualistic relationship between a fungus and photosynthesising algae or cyanobacteria.
  - mycorrhizae are associations between fungi and the roots of higher plants
  - Some of the most fascinating cases of mutualism in nature are seen in plant-pollinator interactions.

Table 13.1 : Population Interactions

Species A	Species B	Name of Interaction
+	+	*Mutualism*
–	–	*Competition*
+	–	*Predation*
+	–	*Parasitism*
+	*0*	*Commensalism*
–	*0*	*Amensalism*

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ECOSYSTEM

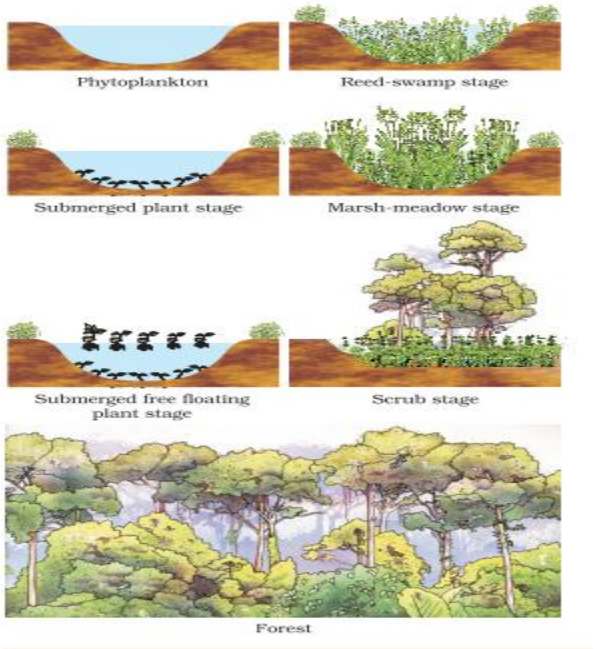
- An ecosystem can be visualised as a functional unit of nature, where living organisms interact among themselves and also with the surrounding physical environment.
- Ecosystem varies greatly in size from a small pond to a large forest or a sea
- **ECOSYSTEM – STRUCTURE AND FUNCTION**
    - Interaction of biotic and abiotic components result in a physical structure that is characteristic for each type of ecosystem.
    - Vertical distribution of different species occupying different levels is called stratification. For example, trees occupy top vertical strata or layer of a forest, shrubs the second and herbs and grasses occupy the bottom layers.
    - There is unidirectional movement of energy towards the higher trophic levels and its dissipation and loss as heat to the environment.
- **PRODUCTIVITY**
    - A constant input of solar energy is the basic requirement for any ecosystem to function and sustain
- **Primary production** is defined as the amount of biomass or organic matter produced per unit area over a time period by plants during photosynthesis.
- The rate of biomass production is called **productivity**
- **Gross primary productivity of an ecosystem is the rate of production of organic matter during photosynthesis.** A considerable amount of GPP is utilised by plants in respiration. Gross primary productivity minus respiration losses (R), is the **net primary productivity (NPP).**
- Net primary productivity is the available biomass for the consumption to heterotrophs (herbiviores and decomposers)

- Secondary productivity is defined as the rate of formation of new organic matter by consumers.
- **DECOMPOSITION**
    - decomposers break down complex organic matter into inorganic substances like carbon dioxide, water and nutrients and the process is called decomposition.
    - Dead plant remains such as leaves, bark, flowers and dead remains of animals, including fecal matter, constitute detritus, which is the raw material for decomposition.
    - humus that is highly resistant to microbial action and undergoes decomposition at an extremely slow rate.
    - Being colloidal in nature it serves as a reservoir of nutrients. The humus is further degraded by some microbes and release of inorganic nutrients occur by the process known as mineralisation.
    - Temperature and soil moisture are the most important climatic factors that regulate decomposition through their effects on the activities of soil microbes. Warm and moist environment favour decomposition whereas low temperature and anaerobiosis inhibit decomposition resulting in build up of organic materials.
- **ENERGY FLOW**
    - Except for the deep sea hydro-thermal ecosystem, sun is the only source of energy for all ecosystems on Earth.
    - Of the incident solar radiation less than 50 per cent of it is photosynthetically active radiation (PAR).
    - ecosystems are not exempt from the Second Law of thermodynamics. They need a constant supply of energy to synthesise the molecules they require, to counteract the universal tendency toward increasing disorderliness.
    - No energy that is trapped into an organism remains in it for ever. The energy trapped by the producer, hence, is either passed on to a consumer or the organism dies. Death of organism is the beginning of the detritus food chain/web.
    - The consumers that feed on these herbivores are carnivores, or more correctly primary carnivores (though secondary consumers). Those animals that depend on the primary carnivores for food are labelled secondary carnivores.
    - The detritus food chain (DFC) begins with dead organic matter. It is made up of decomposers which are heterotrophic organisms, mainly fungi and bacteria. They meet their energy and nutrient requirements by degrading dead organic matter or detritus. These are also known as saprotrophs
    - In an aquatic ecosystem, GFC is the major conduit for energy flow. As against this, in a terrestrial ecosystem, a much larger fraction of energy flows through the detritus food chain than through the GFC.
    - Organisms occupy a place in the natural surroundings or in a community according to their feeding relationship with other organisms. Based on the source

of their nutrition or food, organisms occupy a specific place in the food chain that is known as their trophic level.

- Each trophic level has a certain mass of living material at a particular time called as the standing crop. The standing crop is measured as the mass of living organisms (biomass) or the number in a unit area
- The number of trophic levels in the grazing food chain is restricted as the transfer of energy follows 10 per cent law – only 10 per cent of the energy is transferred to each trophic level from the lower trophic level

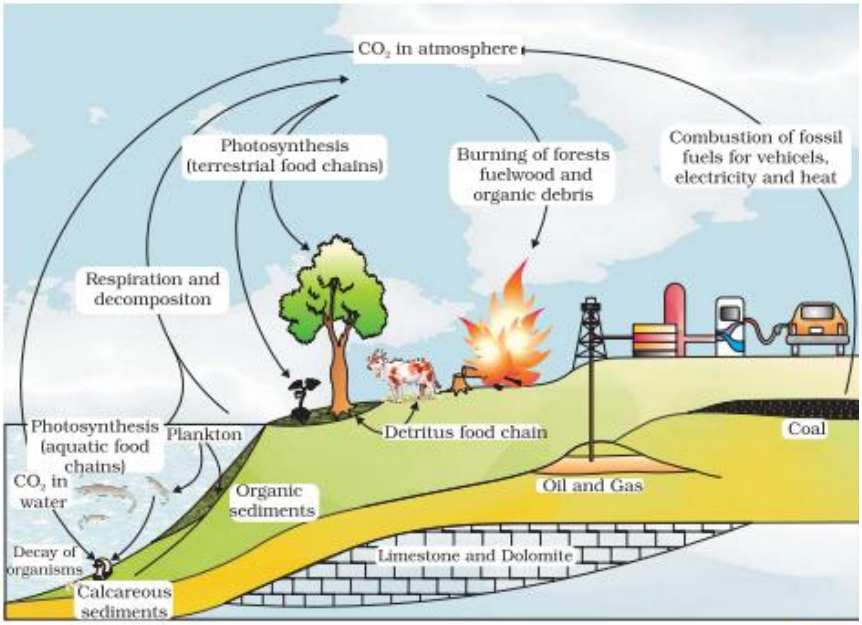
- **ECOLOGICAL PYRAMIDS**
  - the trophic level represents a functional level, not a species as such. A given species may occupy more than one trophic level in the same ecosystem at the same time;
  - In most ecosystems, all the pyramids, of number, of energy and biomass are upright, i.e., producers are more in number and biomass than the herbivores, and herbivores are more in number and biomass than the carnivores. Also energy at a lower trophic level is always more than at a higher level.
  - Pyramid of energy is always upright, can never be inverted, because when energy flows from a particular trophic level to the next trophic level, some energy is always lost as heat at each step. Each bar in the energy pyramid indicates the amount of energy present at each trophic level in a given time or annually per unit area
  - However, there are certain limitations of ecological pyramids such as it does not take into account the same species belonging to two or more trophic levels. It assumes a simple food chain, something that almost never exists in nature; it does not accommodate a food web. Moreover, saprophytes are not given any place in ecological pyramids even though they play a vital role in the ecosystem.
- **ECOLOGICAL SUCCESSION**
  - An important characteristic of all communities is that composition and structure constantly change in response to the changing environmental conditions.
  - These changes lead finally to a community that is in near equilibrium with the environment and that is called a climax community
  - The gradual and fairly predictable change in the species composition of a given area is called ecological succession. During succession some species colonise an area and their populations become more numerous, whereas populations of other species decline and even disappear.
  - The entire sequence of communities that successively change in a given area are called sere(s)
  - The individual transitional communities are termed seral stages or seral communities

- In the successive seral stages there is a change in the diversity of species of organisms, increase in the number of species and organisms as well as an increase in the total biomass.
- Succession is hence a process that starts where no living organisms are there – these could be areas where no living organisms ever existed, say bare rock; or in areas that somehow, lost all the living organisms that existed there. The former is called primary succession, while the latter is termed secondary succession.
- Examples of areas where primary succession occurs are newly cooled lava, bare rock, newly created pond or reservoir
- Before a biotic community of diverse organisms can become established, there must be soil. Depending mostly on the climate, it takes natural processes several hundred to several thousand years to produce fertile soil on bare rock.
- Secondary succession begins in areas where natural biotic communities have been destroyed such as in abandoned farm lands, burned or cut forests, lands that have been flooded.
- Since some soil or sediment is present, succession is faster than primary succession.
- At any time during primary or secondary succession, natural or human induced disturbances (fire, deforestation, etc.), can convert a particular seral stage of succession to an earlier stage. Also such disturbances create new conditions that encourage some species and discourage or eliminate other species.
- 

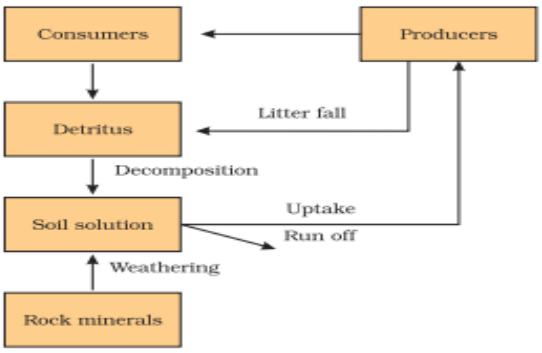
- **Succession of Plants**
  - Hydrarch succession takes place in wetter areas and the successional series progress from hydric to the mesic conditions.

- xerarch succession takes place in dry areas and the series progress from xeric to mesic conditions. Hence, both hydrarch and xerach successions lead to medium water conditions (mesic) – neither too dry (xeric) nor too wet (hydric).
- The species that invade a bare area are called **pioneer species.**
- The climax community remains stable as long as the environment remains unchanged.

- **NUTRIENT CYCLING**
  - The amount of nutrients, such as carbon, nitrogen, phosphorus, calcium, etc., present in the soil at any given time, is referred to as the standing state.
  - The movement of nutrient elements through the various components of an ecosystem is called nutrient cycling. Another name of nutrient cycling is biogeochemical cycles
  - Nutrient cycles are of two types: (a) **gaseous and (b) sedimentary.**
  - reservoir for gaseous type of nutrient cycle (e.g., nitrogen, carbon cycle) exists in the atmosphere and for the sedimentary cycle (e.g., sulphur and phosphorus cycle), the reservoir is located in Earth's crust
  - Environmental factors, e.g., soil, moisture, pH, temperaturer etc., regulate the rate of release of nutrients into the atmosphere.
- **Ecosystem – Carbon Cycle**
  - the composition of living organisms, carbon constitutes 49 per cent of dry weight of organisms and is next only to water
  - 71 per cent carbon is found dissolved in oceans. This oceanic reservoir regulates the amount of carbon dioxide in the atmosphere
  - atmosphere only contains about 1per cent of total global carbon
  - Fossil fuel also represent a reservoir of carbon. Carbon cycling occurs through atmosphere, ocean and through living and dead organisms.
  - Fossil fuel also represent a reservoir of carbon. Carbon cycling occurs through atmosphere, ocean and through living and dead organisms.
  - Some amount of the fixed carbon is lost to sediments and removed from circulation. Burning of wood, forest fire and combustion of organic matter, fossil fuel, volcanic activity are additional sources for releasing CO2 in the atmosphere
  - Human activities have significantly influenced the carbon cycle. Rapid deforestation and massive burning of fossil fuel for energy and transport have significantly increased the rate of release of carbon dioxide into the atmosphere



- **Ecosystem – Phosphorus Cycle**
  - Phosphorus is a major constituent of biological membranes, nucleic acids and cellular energy transfer systems.
  - The natural reservoir of phosphorus is rock, which contains phosphorus in the form of phosphates. When rocks are weathered, minute amounts of these phosphates dissolve in soil solution and are absorbed by the roots of the plants
  - Herbivores and other animals obtain this element from plants. The waste products and the dead organisms are decomposed by phosphate-solubilising bacteria releasing phosphorus. Unlike carbon cycle, there is no respiratory release of phosphorus into atmosphere.
  - The other two major and important differences between carbon and phosphorus cycle are firstly, atmospheric inputs of phosphorus through rainfall are much smaller than carbon inputs,
  - secondly, gaseous exchanges of phosphorus between organism and environment are negligible.



BIODIVERSITY AND CONSERVATION

- BIODIVERSITY
- **Genetic diversity**
  - Each individual species possesses genes which are the source of its own unique features: In human beings, for example, the huge variety of people's faces reflects each person's genetic individuality. The term genetic diversity also covers distinct populations of a single species, such as the thousands of breeds of different dogs or the numerous variety of roses.
  - A single species might show high diversity at the genetic level over its distributional range
- **Species diversity:**
  - The diversity at the species level
  - Species diversity is the number of different species that are represented in a given community
  - Species richness is the number of different species represented in an ecological community, landscape or region
  - Species evenness refers to how close in numbers each species in an environment is
  - For example, the Western Ghats have a greater amphibian species diversity than the Eastern Ghats.
- **Ecological diversity:**
  - This is the number of species in a community of organisms.
  - At the ecosystem level, For many taxonomic groups, species inventories are more complete in temperate than in tropical countries
- More than 70 per cent of all the species recorded are animals, while plants (including algae, fungi, bryophytes, gymnosperms and angiosperms) comprise no more than 22 per cent of the total
- Among animals, insects are the most species-rich taxonomic group, making up more than 70 per cent of the total. That means, out of every 10 animals on this planet, 7 are insects.
- The number of fungi species in the world is more than the combined total of the species of fishes, amphibians, reptiles and mammals.
- **Patterns of Biodiversity**
- **Latitudinal gradients:**
  - The diversity of plants and animals is not uniform throughout the world but shows a rather uneven distribution.
  - In general, species diversity decreases as we move away from the equator towards the poles.
  - With very few exceptions, tropics (latitudinal range of 23.5° N to 23.5° S) harbour more species than temperate or polar areas.
  - **Reasons for higher diversity in tropics**

- **Speciation** is generally a function of time, unlike temperate regions subjected to frequent glaciations in the past, tropical latitudes have remained relatively undisturbed for millions of years and thus, had a long evolutionary time for species diversification
- Tropical environments, unlike temperate ones, are less seasonal, relatively more constant and predictable. Such constant environments promote niche specialisation and lead to a greater species diversity and
- There is more solar energy available in the tropics, which contributes to higher productivity; this in turn might contribute indirectly to greater diversity.

- **Species-Area relationships:**
  - within a region species richness increased with increasing explored area, but only up to a limit.
- **The importance of Species Diversity to the Ecosystem**
  - A stable community should not show too much variation in productivity from year to year; it must be either resistant or resilient to occasional disturbances (natural or man-made), and it must also be resistant to invasions by alien species.
  - increased diversity contributed to higher productivity.
- **Loss of Biodiversity**
  - While it is doubtful if any new species are being added (through speciation) into the earth's treasury of species, there is no doubt about their continuing losses.
  - The biological wealth of our planet has been declining rapidly and the accusing finger is clearly pointing to human activities.
  - Some examples of recent extinctions include the dodo (Mauritius), quagga (Africa), thylacine (Australia), Steller's Sea Cow (Russia) and three subspecies (Bali, Javan, Caspian) of tiger.
  - The difference is in the rates; the current species extinction rates are estimated to be 100 to 1,000 times faster than in the pre-human times and our activities are responsible for the faster rates.
- **In general, loss of biodiversity in a region may lead to**
  - decline in plant production,
  - lowered resistance to environmental perturbations such as drought
  - increased variability in certain ecosystem processes such as plant productivity, water use, and pest and disease cycles.
- **Causes of biodiversity losses:**
  - **Habitat loss and fragmentation:**
    - This is the most important cause driving animals and plants to extinction.
    - The most dramatic examples of habitat loss come from tropical rain forests. Once covering more than 14 per cent of the earth's land surface, these rain forests now cover no more than 6 per cent.

- **Over-exploitation:**
  - Many species extinctions in the last 500 years (Steller's sea cow, passenger pigeon) were due to overexploitation by humans. Presently many marine fish populations around the world are over harvested, endangering the continued existence of some commercially important sp
- **Alien species invasions:**
  - When alien species are introduced unintentionally or deliberately for whatever purpose, some of them turn invasive, and cause decline or extinction of indigenous species.
  - The Nile perch introduced into Lake Victoria in east Africa led eventually to the extinction of an ecologically unique assemblage of more than 200 species of cichlid fish in the lake.
- **Co-extinctions:**
  - When a species becomes extinct, the plant and animal species associated with it in an obligatory way also become extinct.
  - coevolved plant-pollinator mutualism where extinction of one invariably leads to the extinction of the other.

- **BIODIVERSITY CONSERVATION**
- **In situ conservation**
  - **In-situ conservation is the on-site conservation or the conservation of genetic resources in natural populations of plant or animal species, such as forest genetic resources in natural populations of tree species.**
  - They identified for maximum protection certain 'biodiversity hotspots' regions with very high levels of species richness and high degree of endemism (that is, species confined to that region and not found anywhere else)
  - Three of these hotspots – Western Ghats and Sri Lanka, Indo-Burma and Himalaya – cover our country's exceptionally high biodiversity regions
  - In many cultures, tracts of forest were set aside, and all the trees and wildlife within were venerated and given total protection. Such sacred groves are found in Khasi and Jaintia Hills in Meghalaya, Aravalli Hills of Rajasthan, Western Ghat regions of Karnataka and Maharashtra and the Sarguja, Chanda and Bastar areas of Madhya Pradesh. In Meghalaya, the sacred groves are the last refuges for a large number of rare and threatened plants.
- **Ex situ Conservation**
  - In this approach, threatened animals and plants are taken out from their natural habitat and placed in special setting where they can be protected and given special care
  - Zoological parks, botanical gardens and wildlife safari parks serve this purpose.
  - There are many animals that have become extinct in the wild but continue to be maintained in zoological parks

- In recent years ex situ conservation has advanced beyond keeping threatened species in enclosures. Now gametes of threatened species can be preserved in viable and fertile condition for long periods using cryopreservation techniques, eggs can be fertilised in vitro, and plants can be propagated using tissue culture methods. Seeds of different genetic strains of commercially important plants can be kept for long periods in seed banks.

- Biodiversity knows no political boundaries and its conservation is therefore a collective responsibility of all nations. The historic Convention on Biological Diversity **('The Earth Summit')** held in Rio de Janeiro in 1992, called upon all nations to take appropriate measures for conservation of biodiversity and sustainable utilisation of its benefits
- In a follow-up, the World Summit on Sustainable Development held in 2002 in Johannesburg, South Africa, 190 countries pledged their commitment to achieve by 2010, a significant reduction in the current rate of biodiversity loss at global, regional and local levels.
- In in situ conservation, the endangered species are protected in their natural habitat so that the entire ecosystem is protected.

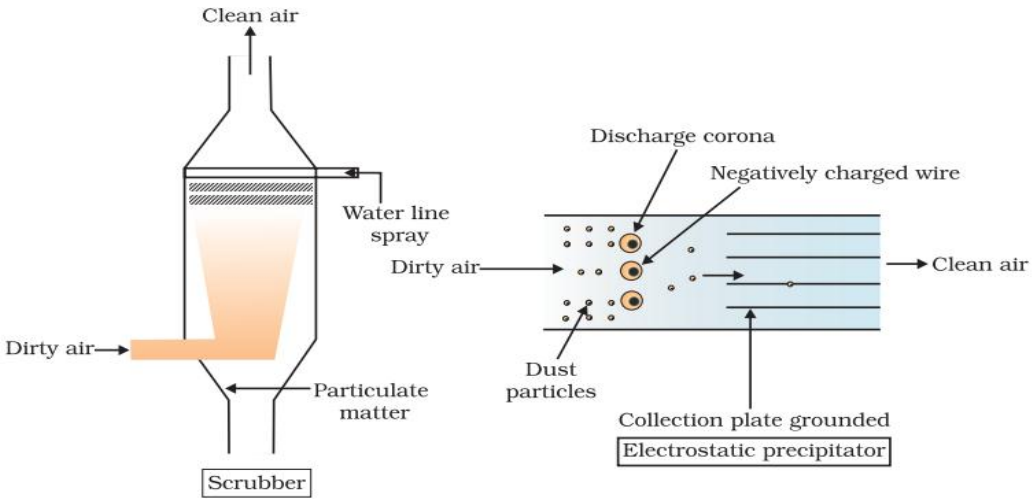
ENVIRONMENTAL ISSUES

- Pollution is any undesirable change in physical, chemical or biological characteristics of air, land, water or soil
- Agents that bring about such an undesirable change are called as pollutants.
- In order to control environmental pollution, the Government of India has passed the Environment (Protection) Act, 1986 to protect and improve the quality of our environment (air, water and soil).
- Pollutants can be solid, liquid or gaseous substances present in greater concentration than in natural abundance and are produced due to human activities or due to natural happenings.
- **AIR POLLUTION AND ITS CONTROL**
  - Air pollutants cause injury to all living organisms. They reduce growth and yield of crops and cause premature death of plants.
  - There are concentric layers of air or regions and each layer has different density. The lowest region of atmosphere in which the human beings along with other organisms live is called troposphere. It extends up to the height of ~ 10 km from sea level
  - Above the troposphere, between 10 and 50 km above sea level lies stratosphere.
  - Troposphere is a turbulent, dusty zone containing air, much water vapour and clouds. This is the region of strong air movement and cloud formation.
  - The stratosphere, on the other hand, contains dinitrogen, dioxygen, ozone and little water vapour.

- Atmospheric pollution is generally studied as tropospheric and stratospheric pollution.
- The presence of ozone in the stratosphere prevents about 99.5 per cent of the sun's harmful ultraviolet (UV) radiations from reaching the earth's surface and thereby protecting humans and other animals from its effect

- **Tropospheric Pollution**
  - Gaseous air pollutants: These are oxides of sulphur, nitrogen and carbon, hydrogen sulphide, hydrocarbons, ozone and other oxidants.
  - Particulate pollutants: These are dust, mist, fumes, smoke, smog etc
  - **Gaseous air pollutants**
  - **Oxides of Sulphur**:
  - Oxides of sulphur are produced when sulphur containing fossil fuel is burnt.
  - sulphur dioxide, is a gas that is poisonous to both animals and plants. It has been reported that even a low concentration of sulphur dioxide causes respiratory diseases e.g., asthma, bronchitis, emphysema in human beings. Sulphur dioxide causes irritation to the eyes, resulting in tears and redness. High concentration of SO 2 leads to stiffness of flower buds which eventually fall off from plants.
  - **Oxides of Nitrogen:**
  - Dinitrogen and dioxygen are the main constituents of air. These gases do not react with each other at a normal temperature. At high altitudes when lightning strikes, they combine to form oxides of nitrogen
  - NO2is oxidised to nitrate ion, NO3 – which is washed into soil, where it serves as a fertilizer.
  - In an automobile engine, (at high temperature) when fossil fuel is burnt, dinitrogen and dioxygen combine to yield significant quantities of nitric oxide (NO) and nitrogen dioxide (NO2)
  - Rate of production of NO2 is faster when nitric oxide reacts with ozone in the stratosphere.
  - The irritant red haze in the traffic and congested places is due to oxides of nitrogen. Higher concentrations of NO2 damage the leaves of plants and retard the rate of photosynthesis. Nitrogen dioxide is a lung irritant that can lead to an acute respiratory disease in children. It is toxic to living tissues also. Nitrogen dioxide is also harmful to various textile fibres and metals.
  - **Hydrocarbons:**
  - Hydrocarbons are composed of hydrogen and carbon only and are formed by incomplete combustion of fuel used in automobiles. Hydrocarbons are carcinogenic, i.e., they cause cancer. They harm plants by causing ageing, breakdown of tissues and shedding of leaves, flowers and twigs.
  - **Oxides of Carbon**

- **Carbon monoxide:**
- It is a colourless and odourless gas, highly poisonous to living beings because of its ability to block the delivery of oxygen to the organs and tissues.
- Delivery of oxygen to the organs and tissues. It is produced as a result of incomplete combustion of carbon.
- Carbon monoxide is mainly released into the air by automobile exhaust. Other sources, which produce CO, involve incomplete combustion of coal, firewood, petrol, etc.
- **carbon monoxide is poisonous because**
- It binds to haemoglobin to form carboxyhaemoglobin, which is about 300 times more stable than the oxygen-haemoglobin complex. In blood, when the concentration of carboxyhaemoglobin reaches about 3–4 per cent, the oxygen carrying capacity of blood is greatly reduced. This oxygen deficiency, results into headache, weak eyesight, nervousness and cardiovascular disorder.
- In pregnant women who have the habit of smoking the increased CO level in blood may induce premature birth, spontaneous abortions and deformed babies.
- **Carbon dioxide:**
- Carbon dioxide (CO2) is released into the atmosphere by respiration, burning of fossil fuels for energy, and by decomposition of limestone during the manufacture of cement.
- Carbon dioxide gas is confined to troposphere only
- Excess of CO2 in the air is removed by green plants and this maintains an appropriate level of CO2 in the atmosphere. Green plants require CO2 for photosynthesis and they, in turn, emit oxygen, thus maintaining the delicate balance. As you know, deforestation and burning of fossil fuel increases the CO 2 level and disturb the balance in the atmosphere. The increased amount of CO 2 in the air is mainly responsible for global warming.
- Air pollutants also deleteriously affect the respiratory system of humans and of animals.
- Smokestacks of thermal power plants, smelters and other industries release particulate and gaseous air pollutants together with harmless gases, such as nitrogen, oxygen, etc. These pollutants must be separated/ filtered out before releasing the harmless gases into the atmosphere.
- There are several ways of removing particulate matter; the most widely used of which is the **electrostatic precipitator**



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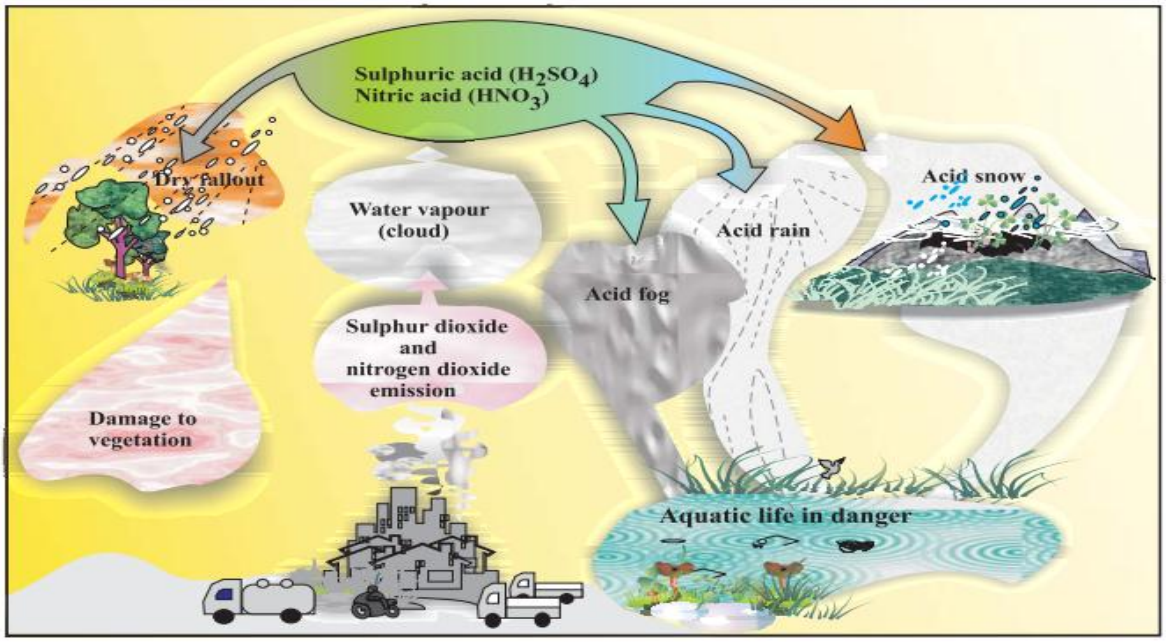
  - It can remove over 99 per cent particulate matter present in the exhaust from a thermal power plant.
  - It has electrode wires that are maintained at several thousand volts, which produce a corona that releases electrons. These electrons attach to dust particles giving them a net negative charge. The collecting plates are grounded and attract the charged dust particles. The velocity of air between the plates must be low enough to allow the dust to fall.
  - A scrubber can remove gases like sulphur dioxide. In a scrubber, the exhaust is passed through a spray of water or lime. Recently we have realised the dangers of particulate matter that are very very small and are not removed by these precipitators. According to Central Pollution Control Board (CPCB), particulate size 2.5 micrometers or less in diameter (PM 2.5) are responsible for causing the greatest harm to human health. These fine particulates can be inhaled deep into the lungs and can cause breathing and respiratory symptoms, irritation, inflammations and damage to the lungs and premature deaths.
  - Proper maintenance of automobiles along with use of lead-free petrol or diesel can reduce the pollutants they emit.
  - Catalytic converters, having expensive metals namely platinum-palladium and rhodium as the catalysts, are fitted into automobiles for reducing emission of poisonous gases.
  - As the exhaust passes through the catalytic converter, unburnt hydrocarbons are converted into carbon dioxide and water, and carbon monoxide and nitric oxide are changed to carbon dioxide and nitrogen gas, respectively.
  - Motor vehicles equipped with catalytic converter should use unleaded petrol because lead in the petrol inactivates the catalyst.
  - In India, the **Air (Prevention and Control of Pollution) Act** came into force in 1981, but was amended in 1987 to include noise as an air pollutant

- Noise is undesired high level of sound.
  - noise causes psychological and physiological disorders in humans.
  - Even chronic exposure to a relatively lower noise level of cities may permanently damage hearing abilities of humans. Noise also causes sleeplessness, increased heart beating, altered breathing pattern, thus considerably stressing humans

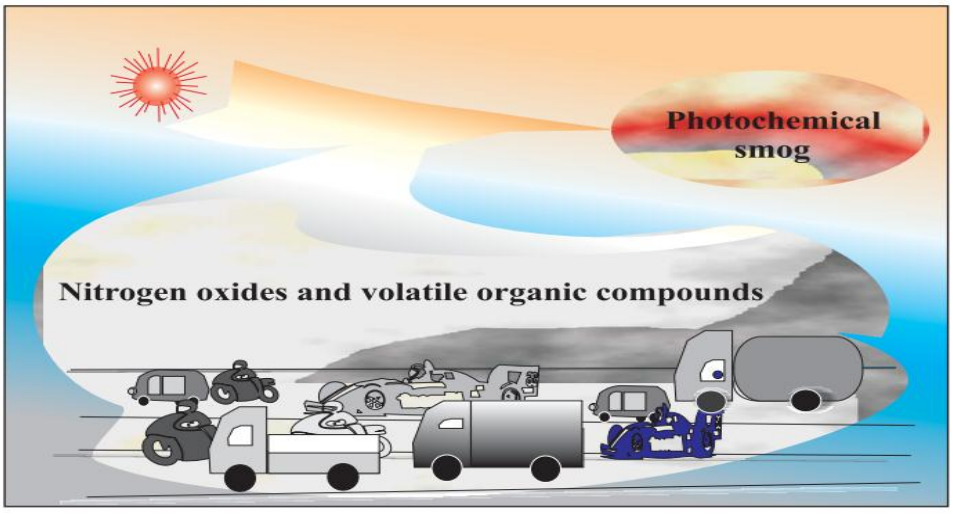
- **Acid rain**
  - normally rain water has a pH of 5.6 due to the presence of H+ ions formed by the reaction of rain water with carbon dioxide present in the atmosphere.
  - When the **pH of the rain water drops below 5.6, it is called acid rain.**
  - Acid rain refers to the ways in which acid from the atmosphere is deposited on the earth's surface
  - Oxides of nitrogen and sulphur which are acidic in nature can be blown by wind along with solid particles in the atmosphere and finally settle down either on the ground as dry deposition or in water, fog and snow as wet deposition
  - burning of fossil fuels (which contain sulphur and nitrogenous matter) such as coal and oil in power stations and furnaces or petrol and diesel in motor engines produce sulphur dioxide and nitrogen oxides. SO2 and NO 2 after oxidation and reaction with water are major contributors to acid rain, because polluted air usually contains particulate matter that catalyse the oxidation



  - Ammonium salts are also formed and can be seen as an atmospheric haze (aerosol of fine particles). Aerosol particles of oxides or ammonium salts in rain drops result in wet deposition. SO2 is also absorbed directly on both solid and liquid ground surfaces and is thus deposited as dry-deposition.

- Acid rain is harmful for agriculture, trees and plants as it dissolves and washes away nutrients needed for their growth. It causes respiratory ailments in human beings and animals. When acid rain falls and flows as groundwater to reach rivers, lakes etc. it affects plants and animal life in aquatic ecosystem. It corrodes water pipes resulting in the leaching of heavy metals such as iron, lead and copper into the drinking water. Acid rain damages buildings and other structures made of stone or metal. The Taj Mahal in India has been affected by acid rain.

- **Particulate Pollutants**
  - Particulates pollutants are the minute solid particles or liquid droplets in air.
  - These are present in vehicle emissions, smoke particles from fires, dust particles and ash from industries.
  - Particulates in the atmosphere may be viable or non-viable. The viable particulates e.g., bacteria, fungi, moulds, algae etc., are minute living organisms that are dispersed in the atmosphere. Human beings are allergic to some of the fungi found in air. They can also cause plant diseases.
  - Non-viable particulates may be classified according to their nature and size as follows:
  - Smoke particulates consist of solid or mixture of solid and liquid particles formed during combustion of organic matter. Examples are cigarette smoke, smoke from burning of fossil fuel, garbage and dry leaves, oil smoke etc.
  - Dust is composed of fine solid particles (over 1µm in diameter), produced during crushing, grinding and attribution of solid materials. Sand from sand blasting, saw dust from wood works, pulverized coal, cement and fly ash from factories, dust storms etc., are some typical examples of this type of particulate emission.
  - Mists are produced by particles of spray liquids and by condensation of vapours in air.
    - Examples are sulphuric acid mist and herbicides and insecticides that miss their targets and travel through air and form mists.
  - Fumes are generally obtained by the condensation of vapours during sublimation, distillation, boiling and several other chemical reactions. Generally, organic solvents, metals and metallic oxides form fume particles
    - The effect of particulate pollutants are largely dependent on the particle size.
  - Particulate pollutants bigger than 5 microns are likely to lodge in the nasal passage, whereas particles of about 1.0 micron enter into lungs easily.
  - Lead used to be a major air pollutant emitted by vehicles. Leaded petrol used to be the primary source of air-borne lead emission in Indian cities.
  - This problem has now been overcome by using unleaded petrol in most of the cities in India. Lead interferes with the development and maturation of red blood cells

- **Smog**
  - The word smog is derived from smoke and fog. This is the most common example of air pollution that occurs in many cities throughout the world.
- **There are two types of smog:**
  - Classical smog occurs in cool humid climate. It is a mixture of smoke, fog and sulphur dioxide. Chemically it is a reducing mixture and so it is also called as reducing smog
  - Photochemical smog occurs in warm, dry and sunny climate. The main components of the photochemical smog result from the action of sunlight on unsaturated hydrocarbons and nitrogen oxides produced by automobiles and factories.
  - Photochemical smog has high concentration of oxidising agents and is, therefore, called as oxidising smog
- **Formation of photochemical smog**
  - When fossil fuels are burnt, a variety of pollutants are emitted into the earth's troposphere
  - Two of the pollutants that are emitted are hydrocarbons (unburnt fuels) and nitric oxide (NO
  - When these pollutants build up to sufficiently high levels, a chain reaction occurs from their interaction with sunlight in which NO is converted into nitrogen dioxide (NO2). This NO2 in turn absorbs energy from sunlight and breaks up into nitric oxide and free oxygen atom
  - 

  - The ozone formed in the above reaction (ii) reacts rapidly with the NO(g) formed in the reaction (i) to regenerate NO2. NO2 is a brown gas and at sufficiently high levels can contribute to haze.

- Ozone is a toxic gas and both NO2 and O3 are strong oxidising agents and can reactwith the unburnt hydrocarbons in the polluted air to produce chemicals such as formaldehyde, acrolein and peroxyacetyl nitrate (PAN).

- **Effects of photochemical smog**
  - The common components of photochemical smog are ozone, nitric oxide, acrolein, formaldehyde and peroxyacetyl nitrate (PAN).
  - Photochemical smog causes serious health problems. Both ozone and PAN act as powerful eye irritants. Ozone and nitric oxide irritate the nose and throat and their high concentration causes headache, chest pain, dryness of the throat, cough and difficulty in breathing. Photochemical smog leads to cracking of rubber and extensive damage to plant life. It also causes corrosion of metals, stones, building materials, rubber and painted surfaces.
  - Many techniques are used to control or reduce the formation of photochemical smog. If we control the primary precursors of photochemical smog, such as NO2 and hydrocarbons, the secondary precursors such as ozone and PAN, the photochemical smog will automatically be reduced.
  - Usually catalytic converters are used in the automobiles, which prevent the release of nitrogen oxide and hydrocarbons to the atmosphere.
  - Certain plants e.g., Pinus, Juniparus, Quercus, Pyrus and Vitis can metabolise nitrogen oxide and therefore, their plantation could help in this matter.
- **Stratospheric Pollution**
  - Formation and Breakdown of Ozone
    - The upper stratosphere consists of considerable amount of ozone (O3), which protects us from the harmful ultraviolet (UV) radiations (λ 255 nm) coming from the sun.
    - These radiations cause skin cancer (melanoma) in humans. Therefore, it is important to maintain the ozone shield.
    - Ozone in the stratosphere is a product of UV radiations acting on dioxygen (O2) molecules. The UV radiations split apart molecular oxygen into free oxygen (O) atoms. These oxygen atoms combine with the molecular oxygen to form ozone.
    - Ozone is thermodynamically unstable and decomposes to molecular oxygen. Thus, a dynamic equilibrium exists between the production and decomposition of ozone molecules.
    - The main reason of ozone layer depletion is believed to be the release of chlorofluorocarbon compounds (CFCs), also known as freons. These compounds are nonreactive, non flammable, non toxic organic molecules and therefore used in refrigerators, air conditioners,
    - in the production of plastic foam and by the electronic industry for cleaning computer parts etc. Once CFCs are released in the atmosphere,

they mix with the normal atmospheric gases and eventually reach the stratosphere. In stratosphere, they get broken down by powerful UV radiations, releasing chlorine free radical.

- The chlorine radical then react with stratospheric ozone to form chlorine monoxide radicals and molecular oxygen.
- Reaction of chlorine monoxide radical with atomic oxygen produces more chlorine radicals.
- The chlorine radicals are continuously regenerated and cause the breakdown of ozone. Thus, CFCs are transporting agents for continuously generating chlorine radicals into the stratosphere and damaging the ozone layer.

- **The Ozone Hole**
  - In 1980s atmospheric scientists working in Antarctica reported about depletion of ozone layer commonly known as ozone hole over the South Pole.
  - It was found that a unique set of conditions was responsible for the ozone hole.
  - In summer season, nitrogen dioxide and methane react with chlorine monoxide (reaction iv) and chlorine atoms (reaction v) forming chlorine sinks, preventing much ozone depletion, whereas in winter, special type of clouds called polar stratospheric clouds are formed over Antarctica.
  - These polar stratospheric clouds provide surface on which chlorine nitrate formed (reaction iv) gets hydrolysed to form hypochlorous acid (reaction (vi)). It also reacts with hydrogen chloride produced as per reaction (v) to give molecular chlorine
  - When sunlight returns to the Antarctica in the spring, the sun's warmth breaks up the clouds and HOCl and Cl 2 are photolysed by sunlight,
  - The chlorine radicals thus formed, initiate the chain reaction for ozone depletion as described earlier.
- **Effects of Depletion of the Ozone Layer**
  - With the depletion of ozone layer, more UV radiation filters into troposphere.
  - UV radiations lead to ageing of skin, cataract, sunburn, skin cancer, killing of many phytoplanktons, damage to fish productivity etc.
  - It has also been reported that plant proteins get easily affected by UV radiations which leads to the harmful mutation of cells
  - It also increases evaporation of surface water through the stomata of the leaves and decreases the moisture content of the soil.
  - Increase in UV radiations damage paints and fibres, causing them to fade faster.
- **WATER POLLUTION AND ITS CONTROL**
  - the Government of India has passed the Water (Prevention and Control of Pollution) Act, 1974 to safeguard our water resources.

- Pollution of water originates from human activities. Through different paths, pollution reaches surface or ground water. Easily identified source or place of pollution is called as **point source.**
- **Non point sources** of pollution are those where a source of pollution cannot be easily identified, e.g., agricultural run off (from farm, animals and crop-lands), acid rain, storm-water drainage (from streets, parking lots and lawns)
- **Causes of Water Pollution**
- **Pathogens:**
  - Pathogens include bacteria and other organisms that enter water from domestic sewage and animal excreta. Human excreta contain bacteria such as Escherichia coli and Streptococcus faecalis which cause gastrointestinal diseases.
- **Organic wastes:**
  - The other major water pollutant is organic matter such as leaves, grass, trash etc.
  - Excessive phytoplankton growth within water is also a cause of water pollution.
  - The large population of bacteria decomposes organic matter present in water. They consume oxygen dissolved in water. The amount of oxygen that water can hold in the solution is limited.
  - If the concentration of dissolved oxygen of water is below 6 ppm, the growth of fish gets inhibited.
  - If too much of organic matter is added to water, all the available oxygen is used up. This causes oxygen dependent aquatic life to die.
  - Thus, the amount of oxygen required by bacteria to break down the organic matter present in a certain volume of a sample of water, is called **Biochemical Oxygen Demand (BOD).**
  - The amount of BOD in the water is a measure of the amount of organic material in the water, in terms of how much oxygen will be required to break it down biologically. Clean water would have BOD value of less than 5 ppm whereas highly polluted water could have a BOD value of 17 ppm or more.
- **Chemical Pollutants:**
  - water soluble inorganic chemicals that include heavy metals such as cadmium, mercury, nickel etc constitute an important class of pollutants. All these metals are dangerous to humans because our body cannot excrete them. Over the time, it crosses the tolerance limit. These metals then can damage kidneys, central nervous system, liver etc.

- This process in which nutrient enriched water bodies support a dense plant population, which kills animal life by depriving it of oxygen and results in subsequent loss of biodiversity is known as Eutrophication.

- **Domestic Sewage and Industrial Effluents**
  - A mere 0.1 per cent impurities make domestic sewage unfit for human use
  - dissolved salts such as nitrates, phosphates, and other nutrients, and toxic metal ions and organic compounds
  - Solids are relatively easy to remove, what Figure 16.2 Composition of waste water is difficult to remove are
  - Domestic sewage primarily contains biodegradable organic matter, which readily decomposes – thanks to bacteria and other micro-organisms, which can multiply using these organic substances as substrates and hence utilise some of the components of sewage.
  - It is possible to estimate the amount of organic matter in sewage water by measuring Biochemical Oxygen Demand (BOD).
  - Micro-organisms involved in biodegradation of organic matter in the receiving water body consume a lot of oxygen, and as a result there is a sharp decline in dissolved oxygen downstream from the point of sewage discharge. This causes mortality of fish and other aquatic creatures
  - Presence of large amounts of nutrients in waters also causes excessive growth of planktonic (free-floating) algae, called an algal bloom which imparts a distinct colour to the water bodies.
  - Algal blooms cause deterioration of the water quality and fish mortality.
  - Sewage from our homes as well from hospitals are likely to contain many undesirable pathogenic microorganisms, and its disposal into a water without proper treatment may cause outbreak of serious diseases, such as, dysentery, typhoid, jaundice, cholera, etc.
  - A few toxic substances, often present in industrial waste waters, can undergo biological magnification (Biomagnification) in the aquatic food chain.
  - **Biomagnification** refers to increase in concentration of the toxicant at successive trophic levels. This happens because a toxic substance accumulated by an organism cannot be metabolised or excreted, and is thus passed on to the next higher trophic level. This phenomenon is well-known for mercury and DDT.
  - In order for biomagnification to occur,the pollutant must be: long-lived,mobile, soluble in fats, biologicallyactive.
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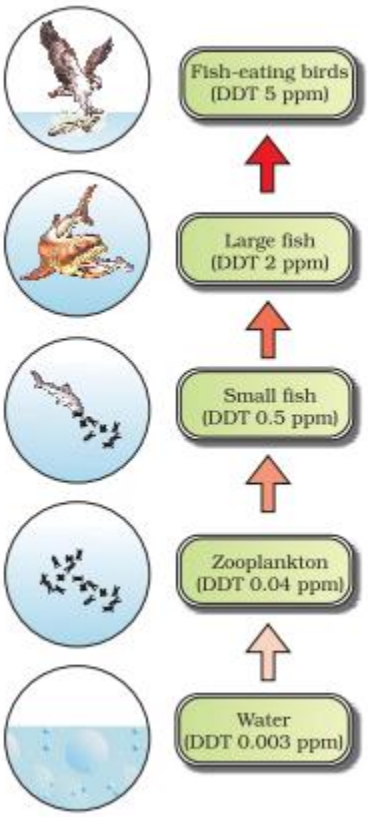


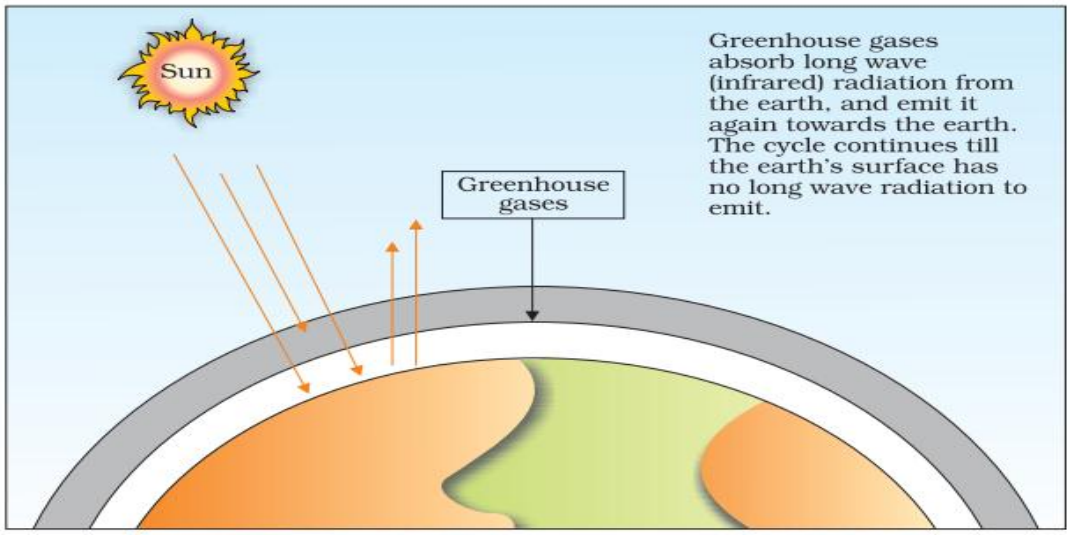
- If a pollutant is short-lived, it will be broken down before it can become dangerous.
- If it is not mobile, it will stay in one place and is unlikely to be taken up by organisms.
- If the pollutant is soluble in water, it will be excreted by the organism.Pollutants that dissolve in fats,however, may be retained for a longtime
- **Eutrophication** is the natural aging of a lake by biological enrichment of its water.
  - In a young lake the water is cold and clear, supporting little life. With time, streams draining into the lake introduce nutrients such as nitrogen and phosphorus, which encourage the growth of aquatic organisms. As the lake's fertility increases, plant and animal life burgeons, and organic remains begin to be deposited on the lake bottom. Over the centuries, as silt and organic debris pile up, the lake grows shallower and warmer, with warm-water organisms supplanting those that thrive in a cold environment. Marsh plants take root in the shallows and begin to fill in the original lake basin. Eventually, the lake gives way to large masses of floating plants (bog), finally converting into land.

- However, pollutants from man's activities like effluents from the industries and homes can radically accelerate the aging process. This phenomenon has been called Cultural or Accelerated Eutrophication.
- The prime contaminants are nitrates and phosphates, which act as plant nutrients. They overstimulate the growth of algae, causing unsightly scum and unpleasant odors, and robbing the water of dissolved oxygen vital to other aquatic life.
- Heated (thermal) wastewaters flowing out of electricity-generating units, e.g., thermal power plants, constitute another important category of pollutants. Thermal wastewater eliminates or reduces the number of organisms sensitive to high temperature, and may enhance the growth of plants and fish in extremely cold areas but, only after causing damage to the indigenous flora and fauna.

- **SOIL POLLUTION**
- **Pesticides**
  - Pesticides are basically synthetic toxic chemicals with ecological repercussions. The repeated use of the same or similar pesticides give rise to pests that are resistant to that
  - group of pesticides thus making the pesticides ineffective.
  - Most of the organic toxins are water insoluble and nonbiodegradable
  - These high persistent toxins are, therefore, transferred from lower trophic level to higher trophic level through food chain
- **INDUSTRIAL WASTE**
  - Non-biodegradable wastes are generated by thermal power plants which produce fly ash; integrated iron and steel plants which produce blast furnace slag and steel melting slag. Industries manufacturing aluminium, zinc and copper produce mud and tailings. Fertilizer industries produce gypsum. Hazardous wastes such as inflammables, composite explosives or highly reactive substances are produced by industries dealing in metals, chemicals, drugs, pharmaceuticals, dyes, pesticides, rubber goods etc
  - New innovations have led to different uses of waste material. Nowadays, fly ash and slag from the steel industry are utilised by the cement industry
- **SOLID WASTES**
  - Solid wastes refer to everything that goes out in trash. Municipal solid wastes are wastes from homes, offices, stores, schools, hospitals, etc., that are collected and disposed by the municipality
  - Sanitary landfills were adopted as the substitute for open-burning dumps. In a sanitary landfill, wastes are dumped in a depression or trench after compaction, and covered with dirt everyday.

- Landfills are also not really much of a solution since the amount of garbage generation specially in the metros has increased so much that these sites are getting filled too. Also there is danger of seepage of chemicals, etc., from these landfills polluting the underground water resources.
- A solution to all this can only be in human beings becoming more sensitive to these environment issues
- All waste that we generate can be categorised into three types – (a) bio-degradable, (b) recyclable and (c) the non-biodegradable.
- The biodegradable materials can be put into deep pits in the ground and be left for natural breakdown.

- **GREENHOUSE EFFECT AND GLOBAL WARMING**
  - The greenhouse effect is a naturally occurring phenomenon that is responsible for heating of Earth's surface and atmosphere
  - without greenhouse effect the average temperature at surface of Earth would have been a chilly –18oC rather than the present average of 15oC.
  - The above-mentioned gases – carbon dioxide and methane – are commonly known as greenhouse gases (Figure 16.7) because they are responsible for the greenhouse effect
- **Global Warming and Greenhouse Effect**



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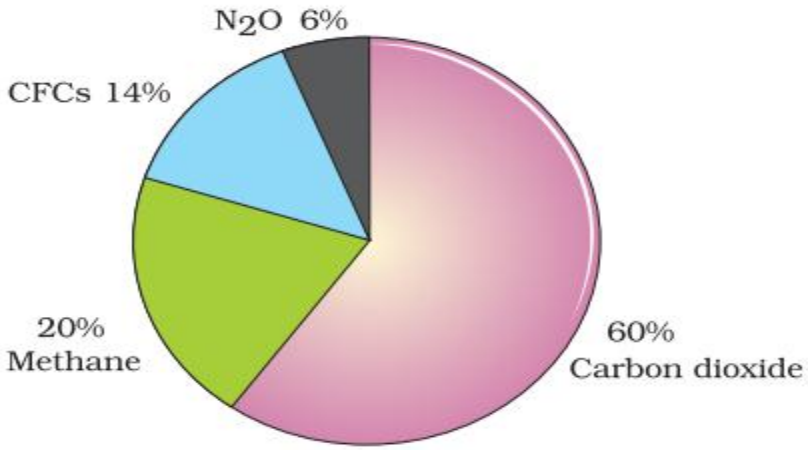
  - About 75 % of the solar energy reaching the earth is absorbed by the earth's surface, which increases its temperature. The rest of the heat radiates back to the atmosphere. Some of the heat is trapped by gases such as carbon dioxide, methane, ozone, chlorofluorocarbon compounds (CFCs) and water vapour in the atmosphere. Thus, they add to the heating of the atmosphere. This causes global warming.

- Just as the glass in a greenhouse holds the sun's warmth inside, atmosphere traps the sun's heat near the earth's surface and keeps it warm. This is called natural greenhouse effect because it maintains the temperature and makes the earth perfect for life.
- Just as the glass in a greenhouse holds the sun's warmth inside, atmosphere traps the sun's heat near the earth's surface and keeps it warm. This is called natural greenhouse effect because it maintains the temperature and makes the earth perfect for life.
- The warm soil and plants emit infrared radiations. Since glass is opaque to infrared (heat) radiations, it partly reflects and partly absorbs these radiations
- Besides carbon dioxide, other greenhouse gases are methane, water vapour, nitrous oxide, CFCs and ozone.
- Methane is produced naturally when vegetation is burnt, digested or rotted in the absence of oxygen. Large amounts of methane are released in paddy fields, coal mines, from rotting garbage dumps and by fossil fuels.



- Chlorofluorocarbons (CFCs) are man-made industrial chemicals used in air conditioning etc. CFCs are also damaging the ozone layer
- Increase in the level of greenhouse gases has led to considerable heating of Earth leading to global warming. During the past century, the temperature of Earth has increased by 0.6 oC
- this rise in temperature is leading to deleterious changes in the environment and resulting in odd climatic changes (e.g. El Nino effect) , thus leading to increased melting of polar ice caps as well as of other places like the Himalayan snow caps.

- **OZONE DEPLETION IN THE STRATOSPHERE**
  - Ozone is found in the upper part of the atmosphere called the stratosphere, and it acts as a shield absorbing ultraviolet radiation from the sun.

- The thickness of the ozone in a column of air from the ground to the top of the atmosphere is measured in terms of Dobson units (DU).
- Ozone gas is continuously formed by the action of UV rays on molecular oxygen, and also degraded into molecular oxygen in the stratosphere.
- There should be a balance between production and degradation of ozone in the stratosphere. Of late, the balance has been disrupted due to enhancement of ozone degradation by chlorofluorocarbons (CFCs). CFCs find wide use as refrigerants. CFCs discharged in the lower part of atmosphere move upward and reach stratosphere. In stratosphere, UV rays act on them releasing Cl atoms. Cl degrades ozone releasing molecular oxygen, with these atoms acting merely as catalysts; Cl atoms are not consumed in the reaction. Hence, whatever CFCs are added to the stratosphere, they have permanent and continuing affects on Ozone
- Although ozone depletion is occurring widely in the stratosphere, the depletion is particularly marked over the Antarctic region. This has resulted in formation of a large area of thinned ozone layer, commonly called as the ozone hole
- UV radiation of wavelengths shorter than UV-B, are almost completely absorbed by Earth's atmosphere, given that the ozone layer is intact. But, UV-B damages DNA and mutation may occur. It causes aging of skin, damage to skin cells and various types of skin cancers. In human eye, cornea absorbs UV-B radiation, and a high dose of UV-B causes inflammation of cornea, called snow-blindness cataract, etc. Such exposure may permanently damage the cornea.
- Montreal Protocol, was signed at Montreal (Canada) in 1987 (effective in 1989) to control the emission of ozone depleting substances.

- **DEGRADATION BY IMPROPER RESOURCE UTILISATION AND MAINTENANCE**
- Soil erosion and desertification:
  - The development of the fertile top-soil takes centuries. But, it can be removed very easily due to human activities like over-cultivation, unrestricted grazing, deforestation and poor irrigation practices, resulting in arid patches of land.
  - **Waterlogging and soil salinity**
    - Irrigation without proper drainage of water leads to waterlogging in the soil.
    - Besides affecting the crops, waterlogging draws salt to the surface of the soil. The salt then is deposited as a thin crust on the land surface or starts collecting at the roots of the plants. This increased salt content is inimical to the growth of crops and is extremely damaging to agriculture.
    - Waterlogging and soil salinity are some of the problems that have come in the wake of the Green Revolution.