ENVIRONMENT

CHAPTER

Environment is the sum total of what is around something or someone. It includes living things and natural forces. The environment of living things provides conditions for development and growth, as well as of danger and damage. Living things do not simply exist in their environment. They constantly interact with it. Organisms change in response to conditions in their environment. The environment consists of the interactions among plants, animals, soil, water, temperature, light, and other living and non-living things.

The word environment is used to talk about many things. People in different fields of knowledge (like history, geography or biology) use the word differently. An electromagnetic environment is the various radio waves that equipment such as radio and radar can meet. Galactic environment refers to conditions between the stars.

But what we are suppose to study here is the natural environment surrounding us. In ecology the environment is all of the natural materials and living things, including sunlight. This is also called the natural environment. Some people call themselves environmentalists. They think we must protect the environment, to keep it safe. The important things in the environment that we value are called natural resources. For example fish, sunlight, and forests. These are renewable natural resources because they come back naturally when we use them. Non-renewable natural resources are important things in the environment that do not come back naturally, for example ores and fossil fuels.

Or we can say, the natural environment encompasses all living and non-living things occurring naturally on Earth or some region thereof. It is an environment that encompasses the interaction of all living species. Climate, weather, and natural resources that affect human survival and economic activity. The concept of the natural environment can be distinguished by components:

- Complete ecological units that function as natural systems without massive civilized human intervention, including all vegetation, microorganisms, soil, rocks, atmosphere, and natural phenomena that occur within their boundaries
- Universal natural resources and physical phenomena that lack clear-cut boundaries, such as air, water, and climate, as well as energy, radiation, electric charge, and magnetism, not originating from civilized human activity

COMPOSITION

Earth science generally recognizes 4 spheres, the lithosphere, the hydrosphere, the atmosphere, and the biosphere as correspondent to rocks, water, air, and life. Some scientists include, as part of the spheres of the Earth, the cryosphere (corresponding to ice) as a distinct portion of the hydrosphere, as well as the pedosphere (corresponding to soil) as an active and intermixed sphere. Earth science (also known as geoscience, the geosciences or the Earth Sciences), is an all-embracing term for the sciences related to the planet Earth. There are four major disciplines in earth sciences, namely geography, geology, geophysics and geodesy. These major disciplines use physics, chemistry, biology, chronology and mathematics to build a qualitative and quantitative understanding of the principal areas or spheres of the Earth.

Out of the above mentioned four spheres that constitutes the subject matter of natural evirinment three sphere namely lithoephere, hydrosphere and atmosphere are the subject matters of Geology, Oceanography and Climatology, although they also constitutes a part of Geography. Only Biosphere is a section which comes under the purview of Environment that too in the form of Ecosystem.

ECOSYSTEM

An 'Ecosystem' is a region with a specific and recognizable landscape form such as forest,

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

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

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

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

At a national or state level, this forms biogeographic regions. There are several distinctive geographical regions in India- the Himalayas, the Gangetic Plains, the Highlands of Central India, the Western and Eastern Ghats, the semi-arid desert in the West, the Deccan Plateau, the Coastal Belts, and the Andaman and Nicobar Islands. These geographically distinctive areas have plants and animals that have been adapted to live in each of these regions.

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

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

1. CONCEPT OF AN ECOSYSTEM

Ecosystem definition: An ecosystem is a natural system consisting of all plants, animals and microorganisms (biotic factors) in an area functioning together with all the non-living physical (abiotic) factors of the environment.

The term ecosystem was coined in 1930 by Roy Clapham, to denote the physical and biological components of an environment considered in relation to each other as a unit. British ecologist Arthur Tansley later refined the term, describing it as the interactive system established between biocoenosis (a group of living creatures) and their biotope (the environment in which they live). Central to the ecosystem concept is the idea that living organisms are continually engaged in a set of relationships with every other element constituting the environment in which they exist. Ecosystems can be bounded and discussed with tremendous variety of scope, and describe any situation where there is relationship between organisms and their environment.

The term ecosystem (a contraction of ecological system) is generally understood as to the entire assemblage of organisms (plant, animal and other living beings—also referred to as a biotic community or biocoenosis) living together in a certain space with their environment (or biotope), functioning as a loose unit. Together, these components and their interactions with and relationships to each other form a dynamic and complex new whole, functioning as an "ecological unit", with additional characteristics that can't be found in the individual components. Nor could any organism live completely on its own without involving any other species of organism.

There are no conceptual restrictions on how large or small a space or an area must be to host an ecosystem, nor on the minimum numbers species or individual organisms to be present.

Early conceptions of an ecosystem were as a structured functional unit in equilibrium of energy

and matter flows among constituent elements. Some considered this vision limited, and preferred to view an ecosystem in terms of cybernetics, which, like any other type of system, is governed by the rules of systems science and cybernetics, as applied specifically to collections of organisms and relevant abiotic components. The branch of ecology that gave rise to this view has become known as systems ecology.

Politically, the concept has become important, since the Convention on Biological Diversity, (CBD), signed by almost 200 nations. The CBD formulates the concept in the following definition: "Ecosystem" means a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit" (Convention on the Biological Diversity, 1992).

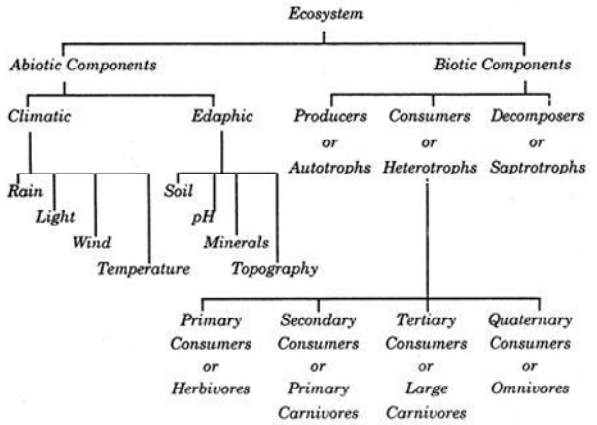
With the need of protecting ecosystems, the political need arose to describe and identify them within a reasonable time and cost-effectively. The IUCN task force on Protected Areas System Composition and Monitoring argued that this could most effectively be achieved using a physiognomic-ecological classification systems, as they are easily recognizable in the field as well as on satellite images. They argued that the structural characteristics - such as forest, savannah, bush-like, prairie vegetations, seasonality of the vegetation and leaf-morphology - complemented with geophysical data - such as elevation, humidity, drainage, salinity of water, characteristics of water bodies - each are determining modifiers that separate partially distinct sets of species. They argued that this is true not only for plant species, but also for species of animals, fungi and bacteria. The degree of ecosystem distinction is subject to the physiognomic classifiers or modifiers that can be recognized on a satellite image and/or in the field. The principle is that physiognomic ecological vegetation classes also represent ecosystem classes, as those vegetation classes represent ecological conditions with partially distinct assemblages of both plants and animal species.

2. STRUCTURE AND FUNCTION OF AN ECOSYSTEM

Structure of an Ecosystem

Ecosystems might be observed in a lot of ways, so there isn't a set of components which make up an ecosystem. However, all ecosystems have to include both abiotic and biotic components, the interactions, and a known source of energy. The simplest but least representative of ecosystems therefore contains just one living plant – the biotic component, in a small terrarium with light exposure to which water source with essential nutrients for the plant's growth has been added – the abiotic environment. The other extreme is the biosphere, which has all of Earth's organisms and the interactions between them and Earth's systems– the abiotic environment. And of course, the majority of ecosystems fall in between the extremes of complexity.

At a core functional level, ecosystems normally contain primary producers able to harvest energy from sunlight by photosynthesis and to use the energy to turn carbon dioxide with other inorganic chemicals in the organic building blocks of life. The consumers feed upon this captured energy, while decomposers not only feed on the energy, but also break up the organic matter into the inorganic constituents, for them to be used again by the producers. Those interactions among the producers and organisms which consume and decompose are called trophic interactions, composed of trophic levels in the energy pyramid, and the most energy and mass are in the primary producers, at the base, while the higher levels of the pyramid, beginning with the primary consumers that feed on primary producers, the secondary consumers which feed on these, and so forth. Trophic interactions are described in a more detailed form as the food chain, which organizes the specific organisms by the trophic distance from the primary producers, and with food webs, which



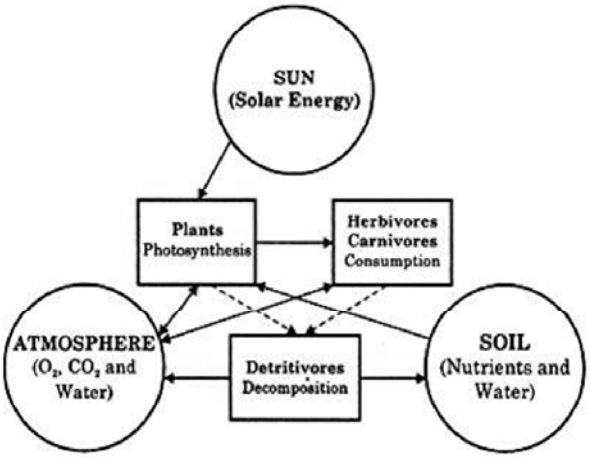
Schematic Representation of the Structure of an Ecosystem.

map the feeding interactions between all the organisms in the ecosystem. Together, the processes of matter cycling and energy transfer are essential in finding out ecosystem function and structure and defining the kinds of interactions between the environment and its organisms. It should also be noted most ecosystems have a wide array of species, and the diversity ought to be considered part and parcel of the ecosystem structure.

Functions of an Ecosystem

By definition, all ecosystems cycle matter and use energy, and the processes define the fundamental ecosystem functions as well. Energetic processes in an ecosystem are normally described by speaking of trophic levels that define the position of organisms according to their level of feeding in comparison to the original energy taken in by primary producers. Always the energy doesn't cycle and ecosystems need a continuous inflow of high-quality energy in order to maintain their function and structure. For this reason, ecosystems are "open systems" needing a net inflow of energy to continue over time - without the sun, our biosphere would shortly run out of energy!

Energy inputs to ecosystems drive the flow of matter within organisms and their environment in a process called biogeochemical cycling. Our biosphere gives a good example of the process, as it exchanges matter with and interacts with the lithosphere, atmosphere and hydrosphere, driving the Earth's biogeochemical cycles of nitrogen, phosphorus, sulfur, carbon and the other elements. An ecosystem process is dynamic, undergoing strong seasonal cycles responding to changes in the solar irradiation; causing fluctuations in the primary productivity; varying the inflow of energy from photosynthesis and carbon dioxide fixation ointo organic materials during the year; driving remarkable annual diversity in the carbon cycle, which is the biggest of all global biogeochemical cycles. The fixed organic carbon in plants becomes then food for decomposers and consumers, who degrade this carbon into forms with less energy, and finally releasing this photosynthesis-fixed carbon back into carbon dioxide in our atmosphere, creating the global carbon cycle. The nitrogen biogeochemical cycling also uses energy, because bacteria fix the nitrogen gas from the atmosphere in reactive forms useful to living organisms with energy from organic materials or from the sun and from plants. Ecosystems cycle sulfur, phosphorus and other elements as well. Because biogeochemical cycles are determined by the transfer of matter between the environment and its organisms, they are good examples of ecosystem-level processes.



Relationship within an Ecosystem.

3. PRODUCERS, CONSUMERS AND DECOMPOSERS

Every living organism is in some way dependent on other organisms. Plants are food for herbivorous animals which are in turn food for carnivorous animals. Thus there are different tropic levels in the ecosystem. Some organisms such as fungi live only on dead material and inorganic matter.

Plants are the 'producers' in the ecosystem as they manufacture their food by using energy from the sun. In the forest these form communities of plant life. In the sea these include tiny algal forms to large seaweed.

The herbivorous animals are primary consumers as they live on the producers. In a forest, these are the insects, amphibia, reptiles, birds and mammals. The herbivorous animals include for example hare, deer and elephants that live on plant life. They graze on grass or feed on the foliage from trees. In grasslands, there are herbivores such as the blackbuck that feed on grass. In the semiarid areas, there are species such as the chinkara or Indian gazelle. In the sea, there are small fish that live on algae and other plants.

At a higher tropic level, there are carnivorous animals, or secondary consumers, which live on herbivorous animals. In our forests, the carnivorous animals are tigers, leopards, jackals, foxes and small wild cats. In the sea, carnivorous fish live on other fish and marine animals. Animals that live in the sea range in size from microscopic forms to giant mammals such as the whale.

Decomposers or detrivores are a group of organisms consisting of small animals like worms, insects, bacteria and fungi, which break down dead organic material into smaller particles and finally into simpler substances that are used by plants as nutrition. Decomposition thus is a vital function in nature, as without this, all the nutrients would be tied up in dead matter and no new life could be produced.

Most ecosystems are highly complex and consist of an extremely large number of individuals of a wide variety of species. In the species-rich tropical ecosystems (such as in our country), only a few species are very common, while most species have relatively few individuals. Some species of plants and animals are extremely rare and may occur only at a few locations. These are said to be 'endemic' to these areas.

When human activities alter the balance in these ecosystems, the "perturbation" leads to the disappearance of these uncommon species. When this happens to an endemic species that is not widely distributed, it becomes extinct for all time.

4. ENERGY FLOW IN THE ECOSYSTEM

In ecology, energy flow, also called the calorific flow, refers to the flow of energy through a food chain. In an ecosystem, ecologists seek to quantify the relative importance of different component species and feeding relationships.

A general energy flow scenario follows:

- Solar energy is fixed by the photoautotrophs, called primary producers, like green plants. Primary consumers absorb most of the stored energy in the plant through digestion, and transform it into the form of energy they need, such as adenosine triphosphate (ATP), through respiration. A part of the energy received by primary consumers, herbivores, is converted to body heat (an effect of respiration), which is radiated away and lost from the system. The loss of energy through body heat is far greater in warm-blooded animals, which must eat much more frequently than those that are cold-blooded. Energy loss also occurs in the expulsion of undigested food (egesta) by excretion or regurgitation.
- Secondary consumers, carnivores, then consume the primary consumers, although omnivores also consume primary producers. Energy that had been used by the primary consumers for growth and storage is thus absorbed into the secondary consumers through the process of digestion. As with primary consumers, secondary consumers convert this energy into a more suitable form (ATP) during respiration. Again, some energy is lost from the system, since energy which the primary consumers had used for respiration and regulation of body temperature cannot be utilised by the secondary consumers.
- Tertiary consumers, which may or may not be apex predators, then consume the secondary consumers, with some energy passed on and some lost, as with the lower levels of the food chain.
- A final link in the food chain are decomposers which break down the organic matter of the tertiary consumers (or whichever consumer is at the top of the chain) and release nutrients into the soil. They also break down plants, herbivores and carnivores that were not eaten by organisms higher on the food chain, as well as the undigested food that is excreted by herbivores and carnivores. Saprotrophic bacteria and fungi are decomposers, and play a pivotal role in the nitrogen and carbon cycles.

The energy is passed on from trophic level to trophic level and each time about 90% of the energy is lost, with some being lost as heat into the environment (an effect of respiration) and some being lost as incompletely digested food. Therefore, primary consumers get about 10% of the energy produced by autotrophs, while secondary consumers get 1% and tertiary consumers get 0.1%.

This means the top consumer of a food chain receives the least energy, as a lot of the food chain's energy has been lost between trophic levels. This loss of energy at each level limits typical food chains to only four to six links.

5. ECOLOGICAL SUCCESSION

Ecological succession is the observed process of change in the species structure of an ecological community over time. The time scale can be decades (for example, after a wildfire), or even millions of years after a mass extinction.

The community begins with relatively few pioneering plants and animals and develops through increasing complexity until it becomes stable or self-perpetuating as a climax community. The "engine" of succession, the cause of ecosystem change, is the impact of established species upon their own environments. A consequence of living is the sometimes subtle and sometimes overt alteration of one's own environment.

It is a phenomenon or process by which an ecological community undergoes more or less orderly and predictable changes following a disturbance or the initial colonization of a new habitat. Succession may be initiated either by formation of new, unoccupied habitat, such as from a lava flow or a severe landslide, or by some form of disturbance of a community, such as from a fire, severe windthrow, or logging. Succession that begins in new habitats, uninfluenced by pre-existing communities is called primary succession, whereas succession that follows disruption of a pre-existing community is called secondary succession.

Factors affecting succession

The trajectory of successional change can be influenced by site conditions, by the character of the events initiating succession (perturbations), by the interactions of the species present, and by more stochastic factors such as availability of colonists or seeds or weather conditions at the time of disturbance. Some of these factors contribute to predictability of succession dynamics; others add more probabilistic elements. Two important perturbation factors today are human actions and climatic change.

In general, communities in early succession will be dominated by fast-growing, well-dispersed species (opportunist, fugitive, or r-selected life-histories). As succession proceeds, these species will tend to be replaced by more competitive (k-selected) species.

Trends in ecosystem and community properties in succession have been suggested, but few appear to be general. For example, species diversity almost necessarily increases during early succession as new species arrive, but may decline in later succession as competition eliminates opportunistic species and leads to dominance by locally superior competitors. Net Primary Productivity, biomass, and trophic properties all show variable patterns over succession, depending on the particular system and site.

Ecological succession was formerly seen as having a stable end-stage called the climax, sometimes referred to as the 'potential vegetation' of a site, and shaped primarily by the local climate. This idea has been largely abandoned by modern ecologists in favor of nonequilibrium ideas of ecosystems dynamics. Most natural ecosystems experience disturbance at a rate that makes a "climax" community unattainable. Climate change often occurs at a rate and frequency sufficient to prevent arrival at a climax state. Additions to available species pools through range expansions and introductions can also continually reshape communities.

The development of some ecosystem attributes, such as soil properties and nutrient cycles, are both influenced by community properties, and, in turn, influence further successional development. This feed-back process may occur only over centuries or millennia. Coupled with the stochastic nature of disturbance events and other long-term (e.g., climatic) changes, such dynamics make it doubtful whether the 'climax' concept ever applies or is particularly useful in considering actual vegetation.

Types

a. Primary, secondary and cyclic succession

Successional dynamics beginning with colonization of an area that has not been previously occupied by an ecological community, such as newly exposed rock or sand surfaces, lava flows, newly exposed glacial tills, etc., are referred to as primary succession. The stages of primary

succession include pioneer plants (lichens and mosses), grassy stage, smaller shrubs, and trees. Animals begin to return when there is food there for them to eat. When it is a fully functioning ecosystem, it has reached the climax community stage. Parts of Acadia National Park in Maine went through primary succession.

Successional dynamics following severe disturbance or removal of a pre-existing community are called secondary succession. Dynamics in secondary succession are strongly influenced by pre-disturbance conditions, including soil development, seed banks, remaining organic matter, and residual living organisms. Because of residual fertility and pre-existing organisms, community change in early stages of secondary succession can be relatively rapid. Woody plants have colonized more rapidly (per unit area) on large and nearby passage.

Secondary succession is much more commonly observed and studied than primary succession. Particularly common types of secondary succession include responses to natural disturbances such as fire, flood, and severe winds, and to human-caused disturbances such as logging and agriculture. Secondary succession has been occurring in Shenedoah National Park following the 1995 flood of the Mormon River, which destroyed plant and animal life. Today, plant and animal species are beginning to return.

b. Seasonal and cyclic dynamics

Unlike secondary succession, these types of vegetation change are not dependent on disturbance but are periodic changes arising from fluctuating species interactions or recurring events. These models modify the climax concept towards one of dynamic states.

c. Causes of plant succession

Autogenic succession can be brought by changes in the soil caused by the organisms there. These changes include accumulation of organic matter in litter or humic layer, alteration of soil nutrients, change in pH of soil by plants growing there. The structure of the plants themselves can also alter the community. For example, when larger species like trees mature, they produce shade on to the developing forest floor that tends to exclude light-requiring species. Shade-tolerant species will invade the area.

Allogenic succession is caused by external environmental influences and not by the vegetation. For example soil changes due to erosion, leaching or the deposition of silt and clays can alter the nutrient content and water relationships in the ecosystems. Animals also play an important role in allogenic changes as they are pollinators, seed dispersers and herbivores. They can also increase nutrient content of the soil in certain areas, or shift soil about (as termites, ants, and moles do) creating patches in the habitat. This may create regeneration sites that favor certain species.

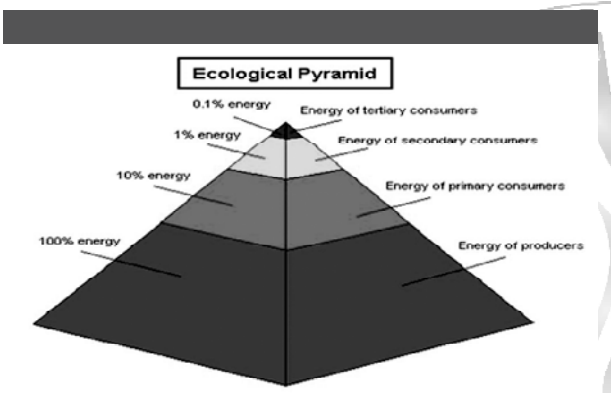
Climatic factors may be very important, but on a much longer time-scale than any other. Changes in temperature and rainfall patterns will promote changes in communities. As the climate warmed at the end of each ice age, great successional changes took place. The tundra vegetation and bare glacial till deposits underwent succession to mixed deciduous forest. The greenhouse effect resulting in increase in temperature is likely to bring profound allogenic changes in the next century. Geological and climatic catastrophes such as volcanic eruptions, earthquakes, avalanches, meteors, floods, fires, and high wind also bring allogenic changes.

6. FOOD CHAINS, FOOD WEBS AND ECOLOGICAL PYRAMIDS

In an ecosystem, plants capture the sun's energy and use it to convert inorganic compounds into energy-rich organic compounds. This process of using the sun's energy to convert minerals (such as magnesium or nitrogen) in the soil into green leaves, or carrots, or strawberries, is called photosynthesis.

Photosynthesis is only the beginning of a chain of energy conversions. There are many types of animals that will eat the products of the photosynthesis process. Examples are deer eating shrub leaves, rabbits eating carrots, or worms eating grass. When these animals eat these plant products, food energy and organic compounds are transferred from the plants to the animals. These animals are in turn eaten by other animals, again transferring energy and organic compounds from one animal to another. Examples would be lions eating zebras, foxes eating rabbits, or birds eating worms.

This chain of energy transferring from one species to another can continue several more times, but it eventually ends. It ends with the dead animals that are broken down and used as food or nutrition by bacteria and fungi. As these organisms, referred to as decomposers, feed from the dead animals, they break down the complex organic compounds into simple nutrients. Decomposers play a very important role in this world because they take care of breaking down (cleaning) many dead material. There are more than 100,000 different types of decomposer organisms! These simpler nutrients are returned to the soil and can be used again by plants. The energy transformation chain starts all over again.



Producers: Organisms, such as plants, that produce their own food are called autotrophs. The autotrophs, as mentioned before, convert inorganic compounds into organic compounds. They are called producers because all of the species of the ecosystem depend on them.

Consumers: All the organisms that can not make their own food (and need producers) are called heterotrophs. In an ecosystem heterotrophs are called consumers because they depend on others. They obtain food by eating other organisms. There are different levels of consumers. Those that feed directly from producers, i.e. organisms that eat plant or plant products are called primary consumers. In the figure above the grasshopper is a primary consumer.

Organisms that feed on primary consumers are called secondary consumers. Those who feed on secondary consumers are tertiary consumers. In the figure above the snake acts as a secondary consumer and the hawk as a tertiary consumer. Some organisms, like the squirrel are at different levels. When the squirrel eats acorns or fruits (which are plant product), it is a primary consumer; however, when it eats insects or nestling birds, it is a tertiary consumer. Consumers are also classified depending on what they eat; they can be herbivores, carnivores, omnivores or scavengers.

In looking at the previous picture, the concept of food chain looks very simple, but in reality it is more complex. Think about it. How many different animals eat grass? And from the Facts about Red-tailed Hawks page, how many different foods does the hawk eat? One doesn't find simple independent food chains in an ecosystem, but many interdependent and complex food chains that look more like a web and are therefore called food webs.

We described in the previous sections how energy and organic compounds are passed from one trophic level to the next. What was not mentioned is the efficiency of the transfer. In a highly efficient transfer almost all of the energy would be transferred — 80% or more. In a low efficiency transfer very little energy would be transferred — less than 20%. In a typical food chain, not all animals or plants are eaten by the next trophic level. In addition, there are portions or materials (such as beaks, shells, bones, etc.) that are also not eaten. That is why the transfer of matter and energy from one trophic level to the next is not an efficient one.

One way to calculate the energy transfer is by measuring or sizing the energy at one trophic level and then at the next. Calorie is a unit of measure used for energy. The energy transfer from one trophic level to the next is about 10%. For example, if there are 10,000 calories at one level, only 1,000 are transferred to the next. This 10% energy and material transfer rule can be depicted with an ecological pyramid that looks like the one below.

This pyramid helps one visualize the fact that in an ecological system there need to be many producing organisms at the bottom of the pyramid to be able to sustain just a couple of organisms at the top. In looking at the pyramid, can you guess how much larger the volume of each layer is as compared to the one just above it? Take a guess. It might not look like it but they are close to 10 times larger.

A basic pyramid shape often represents a typical food chain or food web. The pyramid represents the decrease in the amount of energy, the number

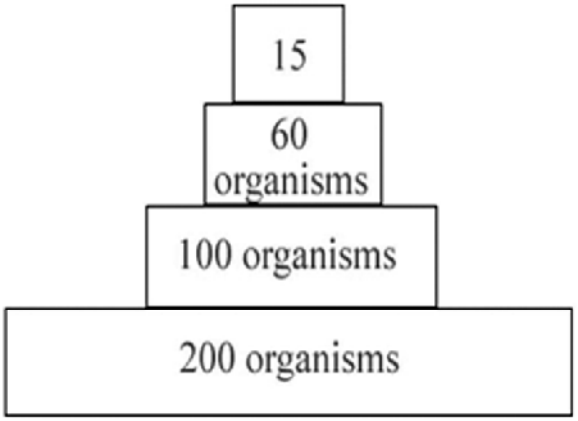
of organisms and the biomass from the producer to the high - order consumer levels. The decrease in the numbers and in the biomass represent the fact that, due to energy loss, fewer organisms can be supported at each successive trophic level.

Pyramid of Energy

Energy is lost between each link in a food chain. Much of the potential energy at each level never reaches the next level. Where does the energy go as it moves through a food chain? Some of the energy that enters a food chain is used as each organism carries out its life functions (i.e. foraging, metabolic processes, reproduction, predator/prey behavior, etc.). Producers manufacture their own food source directly from sunlight by the process of photosynthesis. In order to carry out life functions, consumers acquire energy through the 'burning' or breaking down of food molecules they consume (eat). Thermal energy (heat) is produced as a result of the burning of these food molecules. More than half of the energy from each food molecule is lost as heat. Only about 10% - 20% of energy at each trophic level is available to pass on to the next level. In other words, at each level there is only about 10% available energy to put on new biomass (growth).

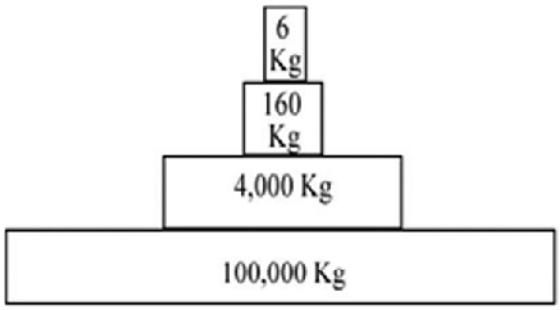
Pyramid of Numbers

The loss of energy at each trophic level also explains why there are usually fewer organisms in each higher trophic level. The total number of plants in a particular area would generally be higher then the number of herbivores that the plants support and the number of herbivores would be higher than the number of higher order carnivores.



Pyramid of Biomass

Biomass is the total mass of dry organic matter per unit of area. Each higher trophic level contains less biomass than the previous trophic level. Therefore a drawing or graph that represents the amount of biomass at each trophic level would also produce the basic pyramid shape. Biomass is related to the abundance of organisms at each trophic level.



7. INTRODUCTION, TYPES, CHARACTERISTIC FEATURES, STRUCTURE AND FUNCTION OF THE FOLLOWING ECOSYSTEM:

a. Forest ecosystem

Forests are formed by a community of plants which is predominantly structurally defined by its trees, shrubs, climbers and ground cover. Natural vegetation looks vastly different from a group of planted trees, which are in orderly rows. The most 'natural' undisturbed forests are located mainly in our National Parks and Wildlife Sanctuaries. The landscapes that make up various types of forests look very different from each other. Their distinctive appearance is a fascinating aspect of nature. Each forest type forms a habitat for a specific community of animals that are adapted to live in it.

The forest ecosystem has two parts

- The non-living or abiotic aspects of the forest: The type of forest depends upon the abiotic conditions at the site. Forests on mountains and hills differ from those along river valleys. Vegetation is specific to the amount of rainfall and the local temperature which varies according to latitude and altitude. Forests also vary in their plant communities in response to the type of soil.

- The living or the biotic aspects of the forest: The plants and animals form communities that are specific to each forest type. For instance coniferous trees occur in the Himalayas. Mangrove trees occur in river deltas. Thorn trees grow in arid areas. The snow leopard lives in the Himalayas while the leopard and tiger live in the forests of the rest of India. Wild sheep and goats live high up in the Himalayas. Many of the birds of the Himalayan forests are different from the rest of India. Evergreen forests of the Western Ghats and North East India are most rich in plant and animal species.

The biotic component includes both the large (macrophytes) and the microscopic plants and animals.

Plants include the trees, shrubs, climbers, grasses, and herbs in the forest. These include species that flower (angiosperms), and non-flowering species (gymnosperms) such as ferns, bryophytes, fungi and algae.

The animals include species of mammals, birds, reptiles, amphibians, fish, insects and other invertebrates and a variety of microscopic animals.

As the plant and animal species are closely dependent on each other, together they form different types of forest communities. Man is a part of these forest ecosystems and the local people depend directly on the forest for several natural resources that act as their life support systems. People who do not live in the forest buy forest products such as wood and paper, which has been extracted from the forest. Thus they use forest produce indirectly from the market.

Forest types in India

The forest type depends upon the abiotic factors such as climate and soil characteristics of a region. Forests in India can be broadly divided into Coniferous forests and Broadleaved forests.

They can also be classified according to the nature of their tree species – evergreen, deciduous, xerophytic or thorn trees, mangroves, etc. They can also be classified according to the most abundant species of trees such as Sal or Teak forests. In many cases a forest is named after the first three or four most abundant tree species.

Coniferous forests grow in the Himalayan mountain region, where the temperatures are low. These forests have tall stately trees with needlelike leaves and downward sloping branches so that the snow can slip off the branches. They have cones instead of seeds and are called gymnosperms.

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

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

Deciduous forests are found in regions with a moderate amount of seasonal rainfall that lasts for only a few months. Most of the forests in which Teak trees grow are of this type. The deciduous trees shed their leaves during the winter and hot summer months. In March or April they regain their fresh leaves just before the monsoon, when they grow vigorously in response to the rains. Thus there are periods of leaf fall and canopy regrowth. The forest frequently has a thick undergrowth as light can penetrate easily onto the forest floor.

Thorn forests are found in the semi- arid regions of India. The trees, which are sparsely distributed, are surrounded by open grassy areas. Thorny plants are called xerophytic species and are able to conserve water. Some of these trees have small leaves, while other species have thick, waxy leaves to reduce water losses during transpiration. Thorn forest trees have long or fibrous roots to reach water at great depths. Many of these plants have thorns, which reduce water loss and protect them from herbivores.

Mangrove forests grow along the coast especially in the river deltas. These plants are able to grow in a mix of saline and fresh water. They grow luxuriantly in muddy areas covered with silt that the rivers have brought down. The mangrove trees have breathing roots that emerge from the mudbanks.

Forest utilisation

Natural forests provide local people with a variety of products if the forest is used carefully. Over-exploitation for fuel wood or timber, and conversion to monoculture plantations for timber or other products, impoverishes local people as the economic benefit goes to people who live elsewhere. The entire resource base on which local people have traditionally survived for generations, is rapidly destroyed. Eventually the forest is completely degraded.

Natural forest ecosystems play an important role in controlling local climate and water regimes. It is well-known that under the canopy of a natural forest, it is cooler than outside the forest.

During the monsoon, the forest retains moisture and slowly releases it through perennial streams during the rest of the year. Plantations fail to perform this function adequately. The loss of forest cover in the catchments of a river thus leads to irreversible changes such as excessive soil erosion, large run-off of surface water during monsoons leading to flash floods, and a shortage of water once the monsoons are over.

Forest products that are collected by people include food such as fruit, roots, herbs and medicinal plants. People depend on fuel-wood to cook food, collect fodder for domestic animals, cut building material for housing, collect medicinal plants that have been known for generations for several ailments and use a variety of non timer forest products such as fiber, cane, gum, to make household articles. Wood from different species of trees have special uses. For instance a soft wood is used for the yok of a bullock cart while a very hard wood is used for its axil. These forest products are of great economic value as they are collected, sold and marketed. Forest dwellers and agricultural people use these goods directly. Other people get them indirectly from the market. Traditional types of agriculture needs forest material such as branches and leaves, which are burnt to form wood ash which acts as a fertiliser for crops such as rice.

Urban people use these forest resources indirectly as all their food and other goods come from agricultural areas that are dependent on the neighbouring forests.

Forest services include the control of the flow of water in streams and rivers. Forest cover reduces surface runoff of rainwater and allows ground water to be stored. Forests prevent erosion of soil. Once soil is lost by erosion, it can take thousands of years to reform. Forests regulate local temperature. It is cooler and more moist under the shade of the trees in the forest. Most importantly, forests absorb carbon dioxide and release oxygen that we breathe.

The wild relatives of our crop plants and fruit trees have special characteristics in their genes which are used to develop new crops and newer varieties of fruit. These newer varieties developed from wild relatives give greater yields or are more resistant to diseases. New industrial products are being produced from the wild plants of the forest. Many of our new medicines come from wild plants.

b. Grassland ecosystem

Grasslands are areas where the vegetation is dominated by grasses (Poaceae), however sedge (Cyperaceae) and rush (Juncaceae) families can also be found. Grasslands occur naturally on all continents except Antarctica. Grasslands are found in most ecoregions of the Earth. For example there are five terrestrial ecoregion classifications (subdivisions) of the temperate grasslands, savannas, and shrublands biome ('ecosystem'), which is one of eight terrestrial ecozones of the Earth's surface.

Vegetation

Grassland vegetation can vary in height from very short, as in chalk grassland, to quite tall, as in the case of North American tallgrass prairie, South American grasslands and African savanna.

Woody plants, shrubs or trees, may occur on some grasslands – forming savannas, scrubby grassland or semi-wooded grassland, such as the African savannas or the Iberian dehesa.

As flowering plants and trees, grasses grow in great concentrations in climates where annual

rainfall ranges between 500 and 900 mm (20 and 35 in). The root systems of perennial grasses and forbs form complex mats that hold the soil in place.

Climate

Grasslands often occur in areas with annual precipitation between 600 mm (24 in) and 1,500 mm (59 in) and average mean annual temperatures ranges from "5 and 20 °C (Woodward et al. 2004). However, some grasslands occur in colder (-20 °C) and hotter (30 °C) climatic conditions. Grassland can exist in habitats that are frequently disturbed by grazing or fire, as such disturbance prevents the encroachment of woody species. Species richness is particularly high in grasslands of low soil fertility such as serpentine barrens and calcareous grasslands. Infertility may also prevent woody encroachment as low nutrient levels in the soil may inhibit the growth of forest and shrub species.most plants from growing. Temperate grasslands occur in temperate climates typified by distinct seasonality (warm summers and cold winters).

Types of Grassland

Tropical and subtropical

These grasslands are classified with tropical and subtropical savannas and shrublands as the tropical and subtropical grasslands, savannas, and shrublands biome. Notable tropical and subtropical grasslands include the Llanos grasslands of South America.

Temperate

Mid-latitude grasslands, including the Prairie and Pacific Grasslands of North America, the Pampas of Argentina, Brazil and Uruguay, calcareous downland, and the steppes of Europe. They are classified with temperate savannas and shrublands as the temperate grasslands, savannas, and shrublands biome. Temperate grasslands are the home to many large herbivores, such as bison, gazelles, zebras, rhinoceroses, and wild horses. Carnivores like lions, wolves and cheetahs and leopards are also found in temperate grasslands. Other animals of this region include: deer, prairie dogs, mice, jack rabbits, skunks, coyotes, snakes, fox, owls, badgers, blackbirds (both Old and New World varieties), grasshoppers, meadowlarks, sparrows, quails, hawks and hyenas.

Flooded

Grasslands that are flooded seasonally or year-round, like the Everglades of Florida, the Pantanal of Brazil, Bolivia and Paraguay or the Esteros del Ibera in Argentina.They are classified with flooded savannas as the flooded grasslands and savannas biome and occur mostly in the tropics and subtropics. Watermeadows are grasslands that are deliberately flooded for short periods.

Montane

High-altitude grasslands located on high mountain ranges around the world, like the Páramo of the Andes Mountains. They are part of the montane grasslands and shrublands biome and also constitute tundra.

Tundra

Similar to montane grasslands, polar arctic tundra can have grasses, but high soil moisture means that few tundras are grass-dominated today. However, during the Pleistocene ice ages, a polar grassland known as steppe-tundra occupied large areas of the Northern hemisphere. These are in the tundra biome.

Desert and xeric

Also called desert grasslands, this is composed of sparse grassland ecoregions located in the deserts and xeric shrublands biome.

Fauna

Mites, insect larvae, nematodes and earthworms inhabit deep soil, which can reach 6 metres (20 ft) underground in undisturbed grasslands on the richest soils of the world. These invertebrates, along with symbiotic fungi, extend the root systems, break apart hard soil, enrich it with urea and other natural fertilizers, trap minerals and water and promote growth. Some types of fungi make the plants more resistant to insect and microbial attacks. Grassland in all its form supports a vast variety of mammals, reptiles, birds, and insects. Typical large mammals include the blue wildebeest, American bison, giant anteater and Przewalski's horse.

While grasslands in general support diverse wildlife, given the lack of hiding places for predators, the African savanna regions support a much greater diversity in wildlife than do temperate grasslands.

There is evidence for grassland being much the product of animal behaviour and movement; some examples include migratory herds of antelope trampling vegetation and African bush elephants eating acacia saplings before the plant has a chance to grow into a mature tree.

c. Desert ecosystem

Desert ecosystem is the sum of the interactions between both biotic and abiotic processes in arid regions, and it includes the interactions of plant, animal, and bacterial populations in a desert habitat, ecosystem, and community. Some of the abiotic factors also include latitude and longitude, soil, and climate. Each of these factors have caused adaptations to the particular environment of the region. The biotic processes include animals and plants and the way they interact. Although deserts have severe climates, some plants still manage to grow. In hot deserts plants are called xerophytic meaning they are able to survive long dry periods. They may close their pores in daytime; they store water in their stems and leaves. Some of these plants include popcorn flower, barrel cactus and Saguaro cactus.

Deserts are most notable for their dry climates resulting from rain-blocking mountain ranges and remoteness from oceanic moisture. Deserts occupy one-fifth of the Earth's land surface and occur in two belts: between 15° and 35° latitude in both the southern and northern hemispheres. These bands are associated with the high solar intensities that all areas in the tropics receive, and being too far from the equator to receive rain from the Intertropical Convergence Zone.

Deserts support diverse communities of plant and animals that have evolved resistance to and methods of circumventing the extreme temperatures and arid conditions. Desert ecology is characterized by dry, alkaline soils, low net production and opportunistic feeding patterns by herbivores and carnivores.

Types and Characteristic Features

One can find at least one desert on every continent except Europe and Antarc-tica. Each desert is different in some way, but they all have one thing in com-mon. In order for an area of land to be considered a desert, it must receive less than 10 inches of water a year.

How come deserts get such little water? Clouds are scarce in these regions, and we all know that without clouds, there can't be rain, snow or any other precipi-tation. But clouds also serve another purpose – they block out some of the Sun. The desert gets mighty hot during the day because the Sun beats down on the sand. At night, the desert gets very cold, because there aren't clouds around to keep the heat from escaping to the atmosphere.

There are plenty of differences between the deserts of the world. Some deserts are made of very fine, red sand, others consist of sand mixed with pebbles and rocks. The desert sand started out as rock, but years of weathering by wind and water has created dunes in the deserts. These sands are mostly minerals, and sometimes oil can be found hidden deep within the rocks.

Structure and Function

The different components of a desert ecosystem are:

(A) Abiotic Component

The abiotic component includes the nutrients present in the soil and the aerial environment. The characteristic feature of the abiotic component is lack of or-ganic matter in the soil and scarcity of water.

(B) Biotic Component

The various biotic components representing three functional groups are:

(a) Producer organisms:

The producers are mainly shrubs or bushes, some grasses and a few trees. Surprisingly, there are many species of plants that survive in the desert. Most of them are succulents, which mean they store water. Others have seeds that lay dormant until a rain awakens them. Regardless, these plants find a way to get water and protect themselves from the heat.

The most famous desert plant is the cactus. There are many species of cacti. The saguaro cactus is the tall, pole shaped cactus. The saguaro can grow up to 40 feet tall. It can hold several tons of water inside its soft tissue. Like all cacti, the saguaro has a thick, waxy layer that protects it from the Sun.

Other succulents include the desert rose and the living rock. This strange plant looks like a spiny rock. It's disguise protects it from predators. The welwitschia is a weird looking plant. It has two

long leaves and a big root. This plant is actually a type of tree and it can live for thousands of years.

There are many other kinds of desert plants. Some of them have thorns others have beautiful flowers and deadly poisons. Even in the worst conditions, these plants continue to thrive.

(b) Consumers

These include animals such as insects and reptiles. Besides them, some rodents, birds and some mammalian vertebrates are also found.

Desert Insects and Arachnids

There are plenty of insects in the desert. One of the most common and destruc-tive pests is the locust. A locust is a special type of grasshopper. They travel from place to place, eating all the vegetation they find. Locusts can destroy many crops in a single day.

Not all desert insects are bad, though. The yucca moth is very important to the yucca plant, because it carries pollen from the flower to the stigma. The darkling beetle has a hard, white, wing case that reflects the Sun's energy. This allows the bug to look for food during the day.

There are also several species of ants in the desert. The harvester ants gather seeds and store them for use during the dry season. And the honey pot ants have a very weird habit. Some members of the colony eat large amounts of sugar, so much that their abdomens get too large for them to move. The rest of the colony feeds off this sugar.

There are also arachnids in the desert. Spiders are the most notable arachnids, but scorpions also belong in this group. Some species of scorpions have poison in their sharp tails. They sting their predators and their prey with the piercing tip.

Desert Reptiles

Reptiles are some of the most interesting creatures of the desert. Reptiles can withstand the extreme temperatures because they can control their body tem-peratures very easily. You can put most of the desert reptiles into one of two categories: snakes and lizards.

Many species of rattlesnakes can be found in the desert. Rattlesnakes have a noisy rattle they use to warn enemies to stay away. If the predator isn't careful, the rattlesnake will strike, injecting venom with its sharp fangs. Other desert snakes include the cobra, king snake and the hognose.

Lizards make up the second category of desert reptiles. They are probably the most bizarre looking animals in the desert. While some change colors and have sharp scales for defense, others change their appearance to look more threaten-ing.

One such creature is the frilled hazard. When enemies are near, the lizard opens its mouth, unveiling a wide frill. This makes the hazard look bigger and scarier. The shingle back has a tail with the same shape as its head. When a predator bites at the tail, the shingle back turns around and bites back. There are only two venomous lizards in the world, and one of them is the gila monster. It has a very painful bite.

Desert Birds

Like the other inhabitants of the desert, birds come up with interesting ways to survive in the harsh climate. The sand grouse has special feathers that soak up water. It can then carry the water to its young trapped in the nest.

Other birds, like the gila woodpecker, depend on the giant saguaro as its home. This woodpecker hollows out a hole in the cactus for a nest. The cool, damp inside is safe for the babies.

The roadrunner is probably the most well known desert bird. Roadrunners are so named because they prefer to run rather than fly. Ostriches also prefer to use their feet. Even the young depend on walking to find food and water. The galah is one of the prettiest desert birds. It is one of the few species that return to the same nest year after year.

Galahs are interesting birds, in that the number of eggs they lay depends on the climate. If the desert is in a drought, they don't lay any. However, during more tolerable years, the galah may lay as many as five eggs.

Desert Mammals

There are several species of mammals in the desert. They range in size from a few inches to several feet in length. Like other desert wildlife, mammals have to find ways to stay cool and drink plenty of water. Many desert mammals are burrowers.

They dig holes in the ground and stay there during the hot days. They return to the surface at night to

feed. Ham-sters, rats and their relatives are all burrowers. Not only do the burrows keep the animals cool, they are also a great place to store food.

Of course, not all animals have in holes in the ground. The kangaroo and spiny anteater both live in the Australian desert region. Spiny anteaters are unusual mammals because they lay eggs.

The desert is also full of wild horses, foxes and jackals, which are part of the canine family. And we can't forget the cats. Lions are found all over the deserts of southern Africa. They get their water from the blood of their prey.

Camels – The Cars of the Desert

Camels could be included in the mammal section. Camels are the cars of the desert. Without them, people would have great difficulty crossing the hot ter-rain. There are two types of camels: Bactrian and dromedary. The main differ-ence between the two is the number of humps. Dromedaries have one hump, and Bactrian have two. Both kinds are used by people, but only Bactrian's are found in the wild.

Camels are great for transportation because they use very little water. Camels can withstand very high temperatures without sweating. They also store fat in their humps for food. If a Bactrian camel travels a long distance without eating, its hump will actually get smaller.

(c) Decomposers

Due to poor vegetation the amount of dead organic matter is very less. As a result the decomposers are very few. The common decomposers are some bacte-ria and fungi, most of which are thermophile.

d. Aquatic ecosystems

An aquatic ecosystem is an ecosystem in a body of water. Communities of organisms that are dependent on each other and on their environment live in aquatic ecosystems. The two main types of aquatic ecosystems are marine ecosystems and freshwater ecosystems.

Types of ecosystem

i. Marine

Marine ecosystems cover approximately 71% of the Earth's surface and contain approximately 97% of the planet's water. They generate 32% of the world's net primary production. They are distinguished from freshwater ecosystems by the presence of dissolved compounds, especially salts, in the water. Approximately 85% of the dissolved materials in seawater are sodium and chlorine. Seawater has an average salinity of 35 parts per thousand (ppt) of water. Actual salinity varies among different marine ecosystems.

Marine ecosystems can be divided into many zones depending upon water depth and shoreline features. The oceanic zone is the vast open part of the ocean where animals such as whales, sharks, and tuna live. The benthic zone consists of substrates below water where many invertebrates live. The intertidal zone is the area between high and low tides; in this figure it is termed the littoral zone. Other near-shore (neritic) zones can include estuaries, salt marshes, coral reefs, lagoons and mangrove swamps. In the deep water, hydrothermal vents may occur where chemosynthetic sulfur bacteria form the base of the food web.

Classes of organisms found in marine ecosystems include brown algae, dinoflagellates, corals, cephalopods, echinoderms, and sharks. Fishes caught in marine ecosystems are the biggest source of commercial foods obtained from wild populations.

Environmental problems concerning marine ecosystems include unsustainable exploitation of marine resources (for example overfishing of certain species), marine pollution, climate change, and building on coastal areas.

ii. Freshwater

Freshwater ecosystems cover 0.80% of the Earth's surface and inhabit 0.009% of its total water. They generate nearly 3% of its net primary production. Freshwater ecosystems contain 41% of the world's known fish species.

There are three basic types of freshwater ecosystems:

- **Lentic:** slow moving water, including pools, ponds, and lakes.
- **Lotic:** faster moving water, for example streams and rivers.
- **Wetlands:** areas where the soil is saturated or inundated for at least part of the time.

❒ Lentic

Lake ecosystems can be divided into zones. One common system divides lakes into three zones (see figure). The first, the littoral zone, is the shallow zone near the shore. This is where rooted wetland plants occur. The offshore is divided into two further zones, an open water zone and a deep water zone. In the open water zone (or photic zone) sunlight supports photosynthetic algae, and the species that feed upon them. In the deep water zone, sunlight is not available and the food web is based on detritus entering from the littoral and photic zones. Some systems use other names. The off shore areas may be called the pelagic zone, and the aphotic zone may be called the profundal zone. Inland from the littoral zone one can also frequently identify a riparian zone which has plants still affected by the presence of the lake—this can include effects from windfalls, spring flooding, and winter ice damage. The production of the lake as a whole is the result of production from plants growing in the littoral zone, combined with production from plankton growing in the open water.

Wetlands can be part of the lentic system, as they form naturally along most lakeshores, the width of the wetland and littoral zone being dependent upon the slope of the shoreline and the amount of natural change in water levels, within and among years. Often dead trees accumulate in this zone, either from windfalls on the shore or logs transported to the site during floods. This woody debris provides important habitat for fish and nesting birds, as well as protecting shorelines from erosion.

Two important subclasses of lakes are ponds, which typically are small lakes that intergrade with wetlands, and water reservoirs. Over long periods of time, lakes, or bays within them, may gradually become enriched by nutrients and slowly fill in with organic sediments, a process called succession. When humans use the watershed, the volumes of sediment entering the lake can accelerate this process. The addition of sediments and nutrients to a lake is known as eutrophication.

Ponds

Ponds are small bodies of freshwater with shallow and still water, marsh, and aquatic plants. They can be further divided into four zones: vegetation zone, open water, bottom mud and surface film. The size and depth of ponds often varies greatly with the time of year; many ponds are produced by spring flooding from rivers. Food webs are based both on free-floating algae and upon aquatic plants. There is usually a diverse array of aquatic life, with a few examples including algae, snails, fish, beetles, water bugs, frogs, turtles, otters and muskrats. Top predators may include large fish, herons, or alligators. Since fish are a major predator upon amphibian larvae, ponds that dry up each year, thereby killing resident fish, provide important refugia for amphibian breeding. Ponds that dry up completely each year are often known as vernal pools. Some ponds are produced by animal activity, including alligator holes and beaver ponds, and these add important diversity to landscapes.

❒ Lotic

The major zones in river ecosystems are determined by the river bed's gradient or by the velocity of the current. Faster moving turbulent water typically contains greater concentrations of dissolved oxygen, which supports greater biodiversity than the slow moving water of pools. These distinctions form the basis for the division of rivers into upland and lowland rivers. The food base of streams within riparian forests is mostly derived from the trees, but wider streams and those that lack a canopy derive the majority of their food base from algae. Anadromous fish are also an important source of nutrients. Environmental threats to rivers include loss of water, dams, chemical pollution and introduced species. A dam produces negative effects that continue down the watershed. The most important negative effects are the reduction of spring flooding, which damages wetlands, and the retention of sediment, which leads to loss of deltaic wetlands.

❒ Wetlands

Wetlands are dominated by vascular plants that have adapted to saturated soil. There are four main types of wetlands: swamp, marsh, fen and bog (both fens and bogs are types of mire). Wetlands are the most productive natural ecosystems in the world because of the proximity of water and soil. Hence they support large numbers of plant and

animal species. Due to their productivity, wetlands are often converted into dry land with dykes and drains and used for agricultural purposes. The construction of dykes, and dams, has negative consequences for individual wetlands and entire watersheds. Their closeness to lakes and rivers means that they are often developed for human settlement. Once settlements are constructed and protected by dykes, the settlements then become vulnerable to land subsidence and ever increasing risk of flooding. The Louisiana coast around New Orleans is a well-known example; the Danube Delta in Europe is another.

Functions

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 regions.

The health of an aquatic ecosystem is degraded when the ecosystem's ability to absorb a stress has been exceeded. A stress on an aquatic ecosystem can be a result of physical, chemical or biological alterations of the environment. Physical alterations include changes in water temperature, water flow and light availability. Chemical alterations include changes in the loading rates of biostimulatory nutrients, oxygen consuming materials, and toxins. Biological alterations include over-harvesting of commercial species and the introduction of exotic species. Human populations can impose excessive stresses on aquatic ecosystems. There are many examples of excessive stresses with negative consequences. Consider three. The environmental history of the Great Lakes of North America illustrates this problem, particularly how multiple stresses, such as water pollution, over-harvesting and invasive species can combine. The Norfolk Broadlands in England illustrate similar decline with pollution and invasive species. Lake Pontchartrain along the Gulf of Mexico illustrates the negative effects of different stresses including levee construction, logging of swamps, invasive species and salt water intrusion.

Abiotic characteristics

An ecosystem is composed of biotic communities that are structured by biological interactions and abiotic environmental factors. Some of the important abiotic environmental factors of aquatic ecosystems include substrate type, water depth, nutrient levels, temperature, salinity, and flow. It is often difficult to determine the relative importance of these factors without rather large experiments. There may be complicated feed back loops. For example, sediment may determine the presence of aquatic plants, but aquatic plants may also trap sediment, and add to the sediment through peat.

The amount of dissolved oxygen in a water body is frequently the key substance in determining the extent and kinds of organic life in the water body. Fish need dissolved oxygen to survive, although their tolerance to low oxygen varies among species; in extreme cases of low oxygen some fish even resort to air gulping. Plants often have to produce aerenchyma, while the shape and size of leaves may also be altered. Conversely, oxygen is fatal to many kinds of anaerobic bacteria. The relative abundance of nitrogen and phosphorus can in effect determine which species of algae come to dominate. Algae are a very important source of food for aquatic life, but at the same time, if they become over-abundant, they can cause declines in fish when they decay. Similar over-abundance of algae in coastal environments such as the Gulf of Mexico produces, upon decay, a hypoxic region of water known as a dead zone.

The salinity of the water body is also a determining factor in the kinds of species found in the water body. Organisms in marine ecosystems tolerate salinity, while many freshwater organisms are intolerant of salt. The degree of salinity in an estuary or delta is an important control upon the type of wetland (fresh, intermediate, or brackish), and the associated animal species. Dams built upstream may reduce spring flooding, and reduce sediment accretion, and may therefore lead to saltwater intrusion in coastal wetlands. Freshwater used for irrigation purposes often absorbs levels of salt that are harmful to freshwater organisms.

Biotic characteristics

The biotic characteristics are mainly determined by the organisms that occur. For example, wetland plants may produce dense canopies that cover large

areas of sediment—or snails or geese may graze the vegetation leaving large mud flats. Aquatic environments have relatively low oxygen levels, forcing adaptation by the organisms found there. For example, many wetland plants must produce aerenchyma to carry oxygen to roots. Other biotic characteristics are more subtle and difficult to measure, such as the relative importance of competition, mutualism or predation. There are a growing number of cases where predation by coastal herbivores including snails, geese and mammals appears to be a dominant biotic factor.

❒ Autotrophic organisms

Autotrophic organisms are producers that generate organic compounds from inorganic material. Algae use solar energy to generate biomass from carbon dioxide and are possibly the most important autotrophic organisms in aquatic environments. Of course, the more shallow the water, the greater the biomass contribution from rooted and floating vascular plants. These two sources combine to produce the extraordinary production of estuaries and wetlands, as this autotrophic biomass is converted into fish, birds, amphibians and other aquatic species.

Chemosynthetic bacteria are found in benthic marine ecosystems. These organisms are able to feed on hydrogen sulfide in water that comes from volcanic vents. Great concentrations of animals that feed on these bacteria are found around volcanic vents. For example, there are giant tube worms (Riftia pachyptila) 1.5 m in length and clams (Calyptogena magnifica) 30 cm long.

❒ Heterotrophic organisms

Heterotrophic organisms consume autotrophic organisms and use the organic compounds in their bodies as energy sources and as raw materials to create their own biomass. Euryhaline organisms are salt tolerant and can survive in marine ecosystems, while stenohaline or salt intolerant species can only live in freshwater environments.

■■■

ENVIRONMENTAL POLLUTION

CHAPTER

Pollution is the effect of undesirable changes in our surroundings that have harmful effects on plants, animals and human beings. This occurs when only short-term economic gains are made at the cost of the long-term ecological benefits for humanity. No natural phenomenon has led to greater ecological changes than have been made by mankind. During the last few decades we have contaminated our air, water and land on which life itself depends with a variety of waste products. Pollutants include solid, liquid or gaseous substances present in greater than natural abundance produced due to human activity, which have a detrimental effect on our environment. The nature and concentration of a pollutant determines the severity of detrimental effects on human health. An average human requires about 12 kg of air each day, which is nearly 12 to15 times greater than the amount of food we eat. Thus even a small concentration of pollutants in the air becomes more significant in comparison to the similar levels present in food. Pollutants that enter water have the ability to spread to distant places especially in the marine ecosystem.

From an ecological perspective pollutants can be classified as follows:

Degradable or non-persistent pollutants: These can be rapidly broken down by natural processes. Eg: domestic sewage, discarded vegetables, etc.

Slowly degradable or persistent pollutants: Pollutants that remain in the environment for many years in an unchanged condition and take decades or longer to degrade. Eg: DDT and most plastics.

Non-degradable pollutants: These cannot be degraded by natural processes. Once they are released into the environment they are difficult to eradicate and continue to accumulate. Eg: toxic elements like lead or mercury.

1. CAUSES, EFFECTS AND CONTROL MEASURES OF

(a) Air Pollution

Pollution is now a common place term, that our ears are attuned to. We hear about the various forms of pollution and read about it through the mass media. Air pollution is one such form that refers to the contamination of the air, irrespective of indoors or outside. A physical, biological or chemical alteration to the air in the atmosphere can be termed as pollution. It occurs when any harmful gases, dust, smoke enters into the atmosphere and makes it difficult for plants, animals and humans to survive as the air becomes dirty.

Air pollution can further be classified into two sections- Visible air pollution and invisible air pollution. Another way of looking at Air pollution could be any substance that holds the potential to hinder the atmosphere or the well being of the living beings surviving in it. The sustainment of all things living is due to a combination of gases that collectively form the atmosphere; the imbalance caused by the increase or decrease of the percentage of these gases can be harmful for survival.

The Ozone layer considered crucial for the existence of the ecosystems on the planet is depleting due to increased pollution. Global warming, a direct result of the increased imbalance of gases in the atmosphere has come to be known as the biggest threat and challenge that the contemporary world has to overcome in a bid for survival.

Types of Pollutants

In order to understand the causes of Air pollution, several divisions can be made. Primarily air pollutants can be caused by primary sources or secondary sources. The pollutants that are a direct result of the process can be called primary pollutants. A classic example of a primary pollutant would be the sulfur-dioxide emitted from factories.

Secondary pollutants are the ones that are caused by the inter mingling and reactions of primary pollutants. Smog created by the interactions of several primary pollutants is known to be as secondary pollutant.

Causes of Air pollution

1. Burning of Fossil Fuels: Sulfur dioxide emitted from the combustion of fossil fuels like coal, petroleum and other factory combustibles is one the major cause of air pollution. Pollution emitting from vehicles including trucks, jeeps, cars, trains, airplanes cause immense amount of pollution. We rely on them to fulfill our daily basic needs of transportation. But, there overuse is killing our environment as dangerous gases are polluting the environment. Carbon Monooxide caused by improper or incomplete combustion and generally emitted from vehicles is another major pollutant along with Nitrogen Oxides, that is produced from both natural and man made processes.
2. Agricultural activities: Ammonia is a very common by product from agriculture related activities and is one of the most hazardous gases in the atmosphere. Use of insecticides, pesticides and fertilizers in agricultural activities has grown quite a lot. They emit harmful chemicals into the air and can also cause water pollution.
3. Exhaust from factories and industries: Manufacturing industries release large amount of carbon monoxide, hydrocarbons, organic compounds, and chemicals into the air thereby depleting the quality of air. Manufacturing industries can be found at every corner of the earth and there is no area that has not been affected by it. Petroleum refineries also release hydrocarbons and various other chemicals that pollute the air and also cause land pollution.
4. Mining operations: Mining is a process wherein minerals below the earth are extracted using large equipments. During the process dust and chemicals are released in the air causing massive air pollution. This is one of the reason which is responsible for the deteriorating health conditions of workers and nearby residents.
5. Indoor air pollution: Household cleaning products, painting supplies emit toxic chemicals in the air and cause air pollution. Have you ever noticed that once you paint walls of your house, it creates some sort of smell which makes it literally impossible for you to breathe.

Suspended particulate matter popular by its acronym SPM, is another cause of pollution. Referring to the particles afloat in the air, SPM is usually caused by dust, combustion etc.

Effects of Air pollution

1. Respiratory and heart problems: The effects of Air pollution are alarming. They are known to create several respiratory and heart conditions along with Cancer, among other threats to the body. Several millions are known to have died due to direct or indirect effects of Air pollution. Children in areas exposed to air pollutants are said to commonly suffer from pneumonia and asthma.
2. Global warming: Another direct effect is the immediate alterations that the world is witnessing due to Global warming. With increased temperatures world wide, increase in sea levels and melting of ice from colder regions and icebergs, displacement and loss of habitat have already signaled an impending disaster if actions for preservation and normalization aren't undertaken soon.
3. Acid Rain: Harmful gases like nitrogen oxides and sulfur oxides are released into the atmosphere during the burning of fossil fuels. When it rains, the water droplets combines with these air pollutants, becomes acidic and then falls on the ground in the form of acid rain. Acid rain can cause great damage to human, animals and crops.
4. Eutrophication: Eutrophication is a condition where high amount of nitrogen present in some pollutants gets developed on sea's surface and turns itself into algae and and adversely affect fish, plants and animal species. The green colored algae that is present on lakes and ponds is due to presence of this chemical only.
5. Effect on Wildlife: Just like humans, animals also face some devastating affects of air pollution. Toxic chemicals present in the air can force wildlife species to move to new place and change their habitat. The toxic pollutants deposit over the surface of the water and can also affect sea animals.
6. Depletion of Ozone layer: Ozone exists in earth's stratosphere and is responsible for protecting humans from harmful ultraviolet

(UV) rays. Earth's ozone layer is depleting due to the presence of chlorofluorocarbons, hydro chlorofluorocarbons in the atmosphere. As ozone layer will go thin, it will emit harmful rays back on earth and can cause skin and eye related problems. UV rays also have the capability to affect crops.

When you try to study the sources of Air pollution, you enlist a series of activities and interactions that create these pollutants. There are two types of sources that we will take a look at: Natural sources and Man-made sources.

Natural sources of pollution include dust carried by the wind from locations with very little or no green cover, gases released from the body processes of living beings (Carbon dioxide from humans during respiration, Methane from cattle during digestion, Oxygen from plants during Photosynthesis). Smoke from the combustion of various inflammable objects, volcanic eruptions etc along with the emission of polluted gases also make it to the list of Natural sources of Pollution.

While looking at the man-made contributions towards air pollution, smoke again features as a prominent component. The smoke emitted from various forms of combustion like in bio mass, factories, vehicles, furnaces etc. Waste used to create landfills generate methane, that is harmful in several ways. The reactions of certain gases and chemicals also form harmful fumes that can be dangerous to the well being of living creatures.

Solutions for Air Pollution

1. Use public mode of transportation: Encourage people to use more and more public modes of transportation to reduce pollution. Also, try to make use of car pooling. If you and your colleagues come from the same locality and have same timings you can explore this option to save energy and money.
2. Conserve energy: Switch off fans and lights when you are going out. Large amount of fossil fuels are burnt to produce electricity. You can save the environment from degradation by reducing the amount of fossil fuels to be burned.
3. Understand the concept of Reduce, Reuse and Recycle: Do not throw away items that are of no use to you. In-fact reuse them for some other purpose. For e.g. you can use old jars to store cereals or pulses.
4. Emphasis on clean energy resources: Clean energy technologies like solar, wind and geothermal are on high these days. Governments of various countries have been providing grants to consumers who are interested in installing solar panels for their home. This will go a long way to curb air pollution.
5. Use energy efficient devices: CFL lights consume less electricity as against their counterparts. They live longer, consume less electricity, lower electricity bills and also help you to reduce pollution by consuming less energy.

Several attempts are being made world wide on a personal, industrial and governmental levels to curb the intensity at which Air Pollution is rising and regain a balance as far as the proportions of the foundation gases are concerned. This is a direct attempt at slacking Global warming. We are seeing a series of innovations and experiments aimed at alternate and unconventional options to reduce pollutants. Air Pollution is one of the larger mirrors of man's follies, and a challenge we need to overcome to see a tomorrow.

(b) Water Pollution

Water pollution is the contamination of water bodies (e.g. lakes, rivers, oceans, aquifers and groundwater). This form of environmental degradation occurs when pollutants are directly or indirectly discharged into water bodies without adequate treatment to remove harmful compounds.

Water pollution affects the entire biosphere – plants and organisms living in these bodies of water. In almost all cases the effect is damaging not only to individual species and population, but also to the natural biological communities.

Categories

Although interrelated, surface water and groundwater have often been studied and managed as separate resources. Surface water seeps through the soil and becomes groundwater. Conversely, groundwater can also feed surface water sources. Sources of surface water pollution are generally grouped into two categories based on their origin.

i. Point sources

Point source water pollution refers to contaminants that enter a waterway from a single,

identifiable source, such as a pipe or ditch. Examples of sources in this category include discharges from a sewage treatment plant, a factory, or a city storm drain.

ii. Nonpoint sources

Nonpoint source pollution refers to diffuse contamination that does not originate from a single discrete source. NPS pollution is often the cumulative effect of small amounts of contaminants gathered from a large area. A common example is the leaching out of nitrogen compounds from fertilized agricultural lands. Nutrient runoff in storm water from "sheet flow" over an agricultural field or a forest are also cited as examples of NPS pollution.

Contaminated storm water washed off of parking lots, roads and highways, called urban runoff, is sometimes included under the category of NPS pollution. However, because this runoff is typically channeled into storm drain systems and discharged through pipes to local surface waters, it becomes a point source.

Causes

The specific contaminants leading to pollution in water include a wide spectrum of chemicals, pathogens, and physical changes such as elevated temperature and discoloration. While many of the chemicals and substances that are regulated may be naturally occurring (calcium, sodium, iron, manganese, etc.) the concentration is often the key in determining what is a natural component of water and what is a contaminant. High concentrations of naturally occurring substances can have negative impacts on aquatic flora and fauna.

Oxygen-depleting substances may be natural materials such as plant matter (e.g. leaves and grass) as well as man-made chemicals. Other natural and anthropogenic substances may cause turbidity (cloudiness) which blocks light and disrupts plant growth, and clogs the gills of some fish species.

Many of the chemical substances are toxic. Pathogens can produce waterborne diseases in either human or animal hosts. Alteration of water's physical chemistry includes acidity (change in pH), electrical conductivity, temperature, and eutrophication. Eutrophication is an increase in the concentration of chemical nutrients in an ecosystem to an extent that increases in the primary productivity of the ecosystem. Depending on the degree of eutrophication, subsequent negative environmental effects such as anoxia (oxygen depletion) and severe reductions in water quality may occur, affecting fish and other animal populations.

Pathogens

Disease-causing microorganisms are referred to as pathogens. Although the vast majority of bacteria are either harmless or beneficial, a few pathogenic bacteria can cause disease. Coliform bacteria, which are not an actual cause of disease, are commonly used as a bacterial indicator of water pollution. Other microorganisms sometimes found in surface waters that have caused human health problems include:

- Burkholderia pseudomallei
- Cryptosporidium parvum
- Giardia lamblia
- Salmonella
- Norovirus and other viruses
- Parasitic worms including the Schistosoma type

High levels of pathogens may result from on-site sanitation systems (septic tanks, pit latrines) or inadequately treated sewage discharges. This can be caused by a sewage plant designed with less than secondary treatment (more typical in less-developed countries). In developed countries, older cities with aging infrastructure may have leaky sewage collection systems (pipes, pumps, valves), which can cause sanitary sewer overflows. Some cities also have combined sewers, which may discharge untreated sewage during rain storms.

Pathogen discharges may also be caused by poorly managed livestock operations.

Causes and other contaminants

Contaminants may include organic and inorganic substances.

i. Organic water pollutants include:

- Detergents
- Disinfection by-products found in chemically disinfected drinking water, such as chloroform

- ❒ Food processing waste, which can include oxygen-demanding substances, fats and grease
- ❒ Insecticides and herbicides, a huge range of organohalides and other chemical compounds
- ❒ Petroleum hydrocarbons, including fuels (gasoline, diesel fuel, jet fuels, and fuel oil) and lubricants (motor oil), and fuel combustion byproducts, from storm water runoff
- ❒ Volatile organic compounds, such as industrial solvents, from improper storage.
- ❒ Chlorinated solvents, which are dense non-aqueous phase liquids, may fall to the bottom of reservoirs, since they don't mix well with water and are denser.
- ❒ Polychlorinated biphenyl (PCBs)
- ❒ Trichloroethylene
- ❒ Perchlorate
- ❒ Various chemical compounds found in personal hygiene and cosmetic products
- ❒ Drug pollution involving pharmaceutical drugs and their metabolites

ii. Inorganic water pollutants include:

- ❒ Acidity caused by industrial discharges (especially sulfur dioxide from power plants)
- ❒ Ammonia from food processing waste
- ❒ Chemical waste as industrial by-products
- ❒ Fertilizers containing nutrients—nitrates and phosphates—which are found in storm water runoff from agriculture, as well as commercial and residential use
- ❒ Heavy metals from motor vehicles (via urban storm water runoff) and acid mine drainage
- ❒ Silt (sediment) in runoff from construction sites, logging, slash and burn practices or land clearing sites.

Macroscopic pollution – large visible items polluting the water – may be termed "floatables" in an urban storm water context, or marine debris when found on the open seas, and can include such items as:

Trash or garbage (e.g. paper, plastic, or food waste) discarded by people on the ground, along with accidental or intentional dumping of rubbish, that are washed by rainfall into storm drains and eventually discharged into surface waters

- ❒ Nurdles, small ubiquitous waterborne plastic pellets
- ❒ Shipwrecks, large derelict ships.

Thermal pollution

Thermal pollution is the rise or fall in the temperature of a natural body of water caused by human influence. Thermal pollution, unlike chemical pollution, results in a change in the physical properties of water. A common cause of thermal pollution is the use of water as a coolant by power plants and industrial manufacturers. Elevated water temperatures decrease oxygen levels, which can kill fish and alter food chain composition, reduce species biodiversity, and foster invasion by new thermophilic species. Urban runoff may also elevate temperature in surface waters.

Thermal pollution can also be caused by the release of very cold water from the base of reservoirs into warmer rivers.

(b) Soil Pollution

With the rise of concrete buildings and roads, one part of the Earth that we rarely see is the soil. It has many different names, such as dirt, mud and ground. However, it is definitely very important to us. The plants that feed us grow in soil and keeping it healthy is essential to maintaining a beautiful planet. However, like all other forms of nature, soil also suffers from pollution. The pollution of soil is a common thing these days, and it happens due to the presence of man made elements.

The main reason why the soil becomes contaminated is due to the presence of man made waste. The waste produced from nature itself such as dead plants, carcasses of animals and rotten fruits and vegetables only adds to the fertility of the soil. However, our waste products are full of chemicals that are not originally found in nature and lead to soil pollution.

Main Causes of Soil Pollution

1. **Industrial Activity:** Industrial activity has been the biggest contributor to the problem in the last century, especially since the amount

of mining and manufacturing has increased. Most industries are dependent on extracting minerals from the Earth. Whether it is iron ore or coal, the by products are contaminated and they are not disposed off in a manner that can be considered safe. As a result, the industrial waste lingers in the soil surface for a long time and makes it unsuitable for use.

2. **Agricultural Activities:** Chemical utilization has gone up tremendously since technology provided us with modern pesticides and fertilizers. They are full of chemicals that are not produced in nature and cannot be broken down by it. As a result, they seep into the ground after they mix with water and slowly reduce the fertility of the soil. Other chemicals damage the composition of the soil and make it easier to erode by water and air. Plants absorb many of these pesticides and when they decompose, they cause soil pollution since they become a part of the land.
3. **Waste Disposal:** Finally, a growing cause for concern is how we dispose of our waste. While industrial waste is sure to cause contamination, there is another way in which we are adding to the pollution. Every human produces a certain amount of personal waste products by way or urine and feces.

   While much of it moves into the sewer the system, there is also a large amount that is dumped directly into landfills in the form of diapers. Even the sewer system ends at the landfill, where the biological waste pollutes the soil and water. This is because our bodies are full of toxins and chemicals which are now seeping into the land and causing pollution of soil.
4. **Accidental Oil Spills:** Oil leaks can happen during storage and transport of chemicals. This can be seen at most of the fuel stations. The chemicals present in the fuel deteriorates the quality of soil and make them unsuitable for cultivation. These chemicals can enter into the groundwater through soil and make the water undrinkable.
5. **Acid Rain:** Acid rain is caused when pollutants present in the air mixes up with the rain and fall back on the ground. The polluted water could dissolve away some of the important nutrients found in soil and change the structure of the soil.

Effects of Soil Pollution

1. **Effect on Health of Humans:** Considering how soil is the reason we are able to sustain ourselves, the contamination of it has major consequences on our health. Crops and plants grown on polluted soil absorb much of the pollution and then pass these on to us. This could explain the sudden surge in small and terminal illnesses.

   Long term exposure to such soil can affect the genetic make-up of the body, causing congenital illnesses and chronic health problems that cannot be cured easily. In fact, it can sicken the livestock to a considerable extent and cause food poisoning over a long period of time. The soil pollution can even lead to widespread famines if the plants are unable to grow in it.
2. **Effect on Growth of Plants:** The ecological balance of any system gets affected due to the widespread contamination of the soil. Most plants are unable to adapt when the chemistry of the soil changes so radically in a short period of time. Fungi and bacteria found in the soil that bind it together begin to decline, which creates an additional problem of soil erosion.

   The fertility slowly diminishes, making land unsuitable for agriculture and any local vegetation to survive. The soil pollution causes large tracts of land to become hazardous to health. Unlike deserts, which are suitable for its native vegetation, such land cannot support most forms of life.
3. **Decreased Soil Fertility:** The toxic chemicals present in the soil can decrease soil fertility and therefore decrease in the soil yield. The contaminated soil is then used to produce fruits and vegetables which lacks quality nutrients and may contain some poisonous substance to cause serious health problems in people consuming them.
4. **Toxic Dust:** The emission of toxic and foul gases from landfills pollutes the environment and causes serious effects on health of some people. The unpleasant smell causes inconvenience to other people.

5. Changes in Soil Structure: The death of many soil organisms (e.g. earthworms) in the soil can lead to alteration in soil structure. Apart from that, it could also force other predators to move to other places in search of food.

A number of ways have been suggested to curb the current rate of pollution. Such attempts at cleaning up the environment require plenty of time and resources to be pitched in. Industries have been given regulations for the disposal of hazardous waste, which aims at minimizing the area that becomes polluted. Organic methods of farming are being supported, which do not use chemical laden pesticides and fertilizers. Use of plants that can remove the pollutants from the soil is being encouraged. However, the road ahead is quite long and the prevention of soil pollution will take many more years.

Solution

Cleanup or environmental remediation is analyzed by environmental scientists who utilize field measurement of soil chemicals and also apply computer models (GIS in Environmental Contamination) for analyzing transport and fate of soil chemicals. There are several principal strategies for remediation:

- Excavate soil and take it to a disposal site away from ready pathways for human or sensitive ecosystem contact. This technique also applies to dredging of bay muds containing toxins.
- Aeration of soils at the contaminated site (with attendant risk of creating air pollution)
- Thermal remediation by introduction of heat to raise subsurface temperatures sufficiently high to volatize chemical contaminants out of the soil for vapour extraction.
- Bioremediation, involving microbial digestion of certain organic chemicals. Techniques used in bioremediation include landfarming, biostimulation and bioaugmentating soil biota with commercially available microflora.
- Extraction of groundwater or soil vapor with an active electromechanical system, with subsequent stripping of the contaminants from the extract.
- Containment of the soil contaminants (such as by capping or paving over in place).
- Phytoremediation, or using plants (such as willow) to extract heavy metals
- Mycoremediation, or using fungus to metabolize contaminants and accumulate heavy metals.

c. Marine Pollution

Marine pollution occurs when harmful, or potentially harmful, effects result from the entry into the ocean of chemicals, particles, industrial, agricultural and residential waste, noise, or the spread of invasive organisms. Most sources of marine pollution are land based. The pollution often comes from nonpoint sources such as agricultural runoff, wind-blown debris and dust. Nutrient pollution, a form of water pollution, refers to contamination by excessive inputs of nutrients. It is a primary cause of eutrophication of surface waters, in which excess nutrients, usually nitrogen or phosphorus, stimulate algae growth.

Many potentially toxic chemicals adhere to tiny particles which are then taken up by plankton and benthos animals, most of which are either deposit or filter feeders. In this way, the toxins are concentrated upward within ocean food chains. Many particles combine chemically in a manner highly depletive of oxygen, causing estuaries to become anoxic.

When pesticides are incorporated into the marine ecosystem, they quickly become absorbed into marine food webs. Once in the food webs, these pesticides can cause mutations, as well as diseases, which can be harmful to humans as well as the entire food web.

Toxic metals can also be introduced into marine food webs. These can cause a change to tissue matter, biochemistry, behaviour, reproduction, and suppress growth in marine life. Also, many animal feeds have a high fish meal or fish hydrolysate content. In this way, marine toxins can be transferred to land animals, and appear later in meat and dairy products.

Sources of Pollution

There are many different ways to categorize, and

examine the inputs of pollution into our marine ecosystems. Generally there are three main types of inputs of pollution into the ocean: direct discharge of waste into the oceans, runoff into the waters due to rain, and pollutants that are released from the atmosphere.

One common path of entry by contaminants to the sea are rivers. The evaporation of water from oceans exceeds precipitation. The balance is restored by rain over the continents entering rivers and then being returned to the sea. The Hudson in New York State and the Raritan in New Jersey, which empty at the northern and southern ends of Staten Island, are a source of mercury contamination of zooplankton (copepods) in the open ocean. The highest concentration in the filter-feeding copepods is not at the mouths of these rivers but 70 miles south, nearer Atlantic City, because water flows close to the coast. It takes a few days before toxins are taken up by the plankton.

Pollution is often classed as point source or nonpoint source pollution. Point source pollution occurs when there is a single, identifiable, and localized source of the pollution. An example is directly discharging sewage and industrial waste into the ocean. Pollution such as this occurs particularly in developing nations. Nonpoint source pollution occurs when the pollution comes from ill-defined and diffuse sources. These can be difficult to regulate. Agricultural runoff and wind blown debris are prime examples.

i. Direct discharge

Pollutants enter rivers and the sea directly from urban sewerage and industrial waste discharges, sometimes in the form of hazardous and toxic wastes.

Inland mining for copper, gold. etc., is another source of marine pollution. Most of the pollution is simply soil, which ends up in rivers flowing to the sea. However, some minerals discharged in the course of the mining can cause problems, such as copper, a common industrial pollutant, which can interfere with the life history and development of coral polyps. Mining has a poor environmental track record. For example, according to the United States Environmental Protection Agency, mining has contaminated portions of the headwaters of over 40% of watersheds in the western continental US. Much of this pollution finishes up in the sea.

ii. Land runoff

Surface runoff from farming, as well as urban runoff and runoff from the construction of roads, buildings, ports, channels, and harbours, can carry soil and particles laden with carbon, nitrogen, phosphorus, and minerals. This nutrient-rich water can cause fleshy algae and phytoplankton to thrive in coastal areas; known as algal blooms, which have the potential to create hypoxic conditions by using all available oxygen.

Polluted runoff from roads and highways can be a significant source of water pollution in coastal areas. About 75% of the toxic chemicals that flow into Puget Sound are carried by stormwater that runs off paved roads and driveways, rooftops, yards and other developed land.

iii. Ship pollution

Ships can pollute waterways and oceans in many ways. Oil spills can have devastating effects. While being toxic to marine life, polycyclic aromatic hydrocarbons (PAHs), found in crude oil, are very difficult to clean up, and last for years in the sediment and marine environment.

Oil spills are probably the most emotive of marine pollution events. However, while a tanker wreck may result in extensive newspaper headlines, much of the oil in the world's seas comes from other smaller sources, such as tankers discharging ballast water from oil tanks used on return ships, leaking pipelines or engine oil disposed of down sewers.

Discharge of cargo residues from bulk carriers can pollute ports, waterways and oceans. In many instances vessels intentionally discharge illegal wastes despite foreign and domestic regulation prohibiting such actions. It has been estimated that container ships lose over 10,000 containers at sea each year (usually during storms). Ships also create noise pollution that disturbs natural wildlife, and water from ballast tanks can spread harmful algae and other invasive species.

Ballast water taken up at sea and released in port is a major source of unwanted exotic marine life. The invasive freshwater zebra mussels, native to the Black, Caspian and Azov seas, were probably transported to the Great Lakes via ballast water from a transoceanic vessel. One of the worst cases of a single invasive species causing harm to an

ecosystem can be attributed to a seemingly harmless jellyfish. Mnemiopsis leidyi, a species of comb jellyfish that spread so it now inhabits estuaries in many parts of the world. It was first introduced in 1982, and thought to have been transported to the Black Sea in a ship's ballast water. The population of the jellyfish shot up exponentially and, by 1988, it was wreaking havoc upon the local fishing industry. "The anchovy catch fell from 204,000 tons in 1984 to 200 tons in 1993; sprat from 24,600 tons in 1984 to 12,000 tons in 1993; horse mackerel from 4,000 tons in 1984 to zero in 1993." Now that the jellyfish have exhausted the zooplankton, including fish larvae, their numbers have fallen dramatically, yet they continue to maintain a stranglehold on the ecosystem.

Invasive species can take over once occupied areas, facilitate the spread of new diseases, introduce new genetic material, alter underwater seascapes and jeopardize the ability of native species to obtain food. Invasive species are responsible for about $138 billion annually in lost revenue and management costs in the US alone.

iv. Atmospheric pollution

Another pathway of pollution occurs through the atmosphere. Wind blown dust and debris, including plastic bags, are blown seaward from landfills and other areas. Dust from the Sahara moving around the southern periphery of the subtropical ridge moves into the Caribbean and Florida during the warm season as the ridge builds and moves northward through the subtropical Atlantic. Dust can also be attributed to a global transport from the Gobi and Taklamakan deserts across Korea, Japan, and the Northern Pacific to the Hawaiian Islands. Since 1970, dust outbreaks have worsened due to periods of drought in Africa. There is a large variability in dust transport to the Caribbean and Florida from year to year; however, the flux is greater during positive phases of the North Atlantic Oscillation. The USGS links dust events to a decline in the health of coral reefs across the Caribbean and Florida, primarily since the 1970s.

Climate change is raising ocean temperatures and raising levels of carbon dioxide in the atmosphere. These rising levels of carbon dioxide are acidifying the oceans. This, in turn, is altering aquatic ecosystems and modifying fish distributions, with impacts on the sustainability of fisheries and the livelihoods of the communities that depend on them. Healthy ocean ecosystems are also important for the mitigation of climate change.

v. Deep sea mining

Deep sea mining is a relatively new mineral retrieval process that takes place on the ocean floor. Ocean mining sites are usually around large areas of polymetallic nodules or active and extinct hydrothermal vents at about 1,400 – 3,700 meters below the ocean's surface. The vents create sulfide deposits, which contain precious metals such as silver, gold, copper, manganese, cobalt, and zinc. The deposits are mined using either hydraulic pumps or bucket systems that take ore to the surface to be processed. As with all mining operations, deep sea mining raises questions about environmental damages to the surrounding areas.

Because deep sea mining is a relatively new field, the complete consequences of full scale mining operations are unknown. However, experts are certain that removal of parts of the sea floor will result in disturbances to the benthic layer, increased toxicity of the water column and sediment plumes from tailings. Removing parts of the sea floor disturbs the habitat of benthic organisms, possibly, depending on the type of mining and location, causing permanent disturbances. Aside from direct impact of mining the area, leakage, spills and corrosion would alter the mining area's chemical makeup.

Among the impacts of deep sea mining, sediment plumes could have the greatest impact. Plumes are caused when the tailings from mining (usually fine particles) are dumped back into the ocean, creating a cloud of particles floating in the water. Two types of plumes occur: near bottom plumes and surface plumes. Near bottom plumes occur when the tailings are pumped back down to the mining site. The floating particles increase the turbidity, or cloudiness, of the water, clogging filter-feeding apparatuses used by benthic organisms. Surface plumes cause a more serious problem. Depending on the size of the particles and water currents the plumes could spread over vast areas. The plumes could impact zooplankton and light penetration, in turn affecting the food web of the area.

Types of pollution

i. Acidification

The oceans are normally a natural carbon sink, absorbing carbon dioxide from the atmosphere. Because the levels of atmospheric carbon dioxide are increasing, the oceans are becoming more acidic. The potential consequences of ocean acidification are not fully understood, but there are concerns that structures made of calcium carbonate may become vulnerable to dissolution, affecting corals and the ability of shellfish to form shells.

Oceans and coastal ecosystems play an important role in the global carbon cycle and have removed about 25% of the carbon dioxide emitted by human activities between 2000 and 2007 and about half the anthropogenic CO2 released since the start of the industrial revolution. Rising ocean temperatures and ocean acidification means that the capacity of the ocean carbon sink will gradually get weaker, giving rise to global concerns expressed in the Monaco and Manado Declarations.

A report from NOAA scientists published in the journal Science in May 2008 found that large amounts of relatively acidified water are upwelling to within four miles of the Pacific continental shelf area of North America. This area is a critical zone where most local marine life lives or is born. While the paper dealt only with areas from Vancouver to northern California, other continental shelf areas may be experiencing similar effects.

A related issue is the methane clathrate reservoirs found under sediments on the ocean floors. These trap large amounts of the greenhouse gas methane, which ocean warming has the potential to release. In 2004 the global inventory of ocean methane clathrates was estimated to occupy between one and five million cubic kilometres. If all these clathrates were to be spread uniformly across the ocean floor, this would translate to a thickness between three and fourteen metres. This estimate corresponds to 500–2500 gigatonnes carbon (Gt C), and can be compared with the 5000 Gt C estimated for all other fossil fuel reserves.

ii. Eutrophication

Eutrophication is an increase in chemical nutrients, typically compounds containing nitrogen or phosphorus, in an ecosystem. It can result in an increase in the ecosystem's primary productivity (excessive plant growth and decay), and further effects including lack of oxygen and severe reductions in water quality, fish, and other animal populations.

The biggest culprit are rivers that empty into the ocean, and with it the many chemicals used as fertilizers in agriculture as well as waste from livestock and humans. An excess of oxygen depleting chemicals in the water can lead to hypoxia and the creation of a dead zone.

Estuaries tend to be naturally eutrophic because land-derived nutrients are concentrated where runoff enters the marine environment in a confined channel. The World Resources Institute has identified 375 hypoxic coastal zones around the world, concentrated in coastal areas in Western Europe, the Eastern and Southern coasts of the US, and East Asia, particularly in Japan. In the ocean, there are frequent red tide algae blooms that kill fish and marine mammals and cause respiratory problems in humans and some domestic animals when the blooms reach close to shore.

In addition to land runoff, atmospheric anthropogenic fixed nitrogen can enter the open ocean. A study in 2008 found that this could account for around one third of the ocean's external (non-recycled) nitrogen supply and up to three per cent of the annual new marine biological production. It has been suggested that accumulating reactive nitrogen in the environment may have consequences as serious as putting carbon dioxide in the atmosphere.

One proposed solution to eutrophication in estuaries is to restore shellfish populations, such as oysters. Oyster reefs remove nitrogen from the water column and filter out suspended solids, subsequently reducing the likelihood or extent of harmful algal blooms or anoxic conditions. Filter feeding activity is considered beneficial to water quality by controlling phytoplankton density and sequestering nutrients, which can be removed from the system through shellfish harvest, buried in the sediments, or lost through denitrification. Foundational work toward the idea of improving marine water quality through shellfish cultivation to was conducted by Odd Lindahl et al., using mussels in Sweden.

iii. Plastic debris

Marine debris is mainly discarded human rubbish which floats on, or is suspended in the ocean. Eighty percent of marine debris is plastic – a component that has been rapidly accumulating since the end of World War II. The mass of plastic in the oceans may be as high as one hundred million metric tons.

Discarded plastic bags, six pack rings and other forms of plastic waste which finish up in the ocean present dangers to wildlife and fisheries. Aquatic life can be threatened through entanglement, suffocation, and ingestion. Fishing nets, usually made of plastic, can be left or lost in the ocean by fishermen. Known as ghost nets, these entangle fish, dolphins, sea turtles, sharks, dugongs, crocodiles, seabirds, crabs, and other creatures, restricting movement, causing starvation, laceration and infection, and, in those that need to return to the surface to breathe, suffocation.

Many animals that live on or in the sea consume flotsam by mistake, as it often looks similar to their natural prey. Plastic debris, when bulky or tangled, is difficult to pass, and may become permanently lodged in the digestive tracts of these animals. Especially when evolutionary adaptions make it impossible for the likes of turtles to reject plastic bags, which resemble jellyfish when immersed in water, as they have a system in their throat to stop slippery foods from otherwise escaping. Thereby blocking the passage of food and causing death through starvation or infection.

Plastics accumulate because they don't biodegrade in the way many other substances do. They will photodegrade on exposure to the sun, but they do so properly only under dry conditions, and water inhibits this process. In marine environments, photodegraded plastic disintegrates into ever smaller pieces while remaining polymers, even down to the molecular level. When floating plastic particles photodegrade down to zooplankton sizes, jellyfish attempt to consume them, and in this way the plastic enters the ocean food chain. Many of these long-lasting pieces end up in the stomachs of marine birds and animals, including sea turtles, and black-footed albatross.

Plastic debris tends to accumulate at the centre of ocean gyres. In particular, the Great Pacific Garbage Patch has a very high level of plastic particulate suspended in the upper water column. In samples taken in 1999, the mass of plastic exceeded that of zooplankton (the dominant animal life in the area) by a factor of six. Midway Atoll, in common with all the Hawaiian Islands, receives substantial amounts of debris from the garbage patch. Ninety percent plastic, this debris accumulates on the beaches of Midway where it becomes a hazard to the bird population of the island. Midway Atoll is home to two-thirds (1.5 million) of the global population of Laysan Albatross. Nearly all of these albatross have plastic in their digestive system and one-third of their chicks die.

Toxic additives used in the manufacture of plastic materials can leach out into their surroundings when exposed to water. Waterborne hydrophobic pollutants collect and magnify on the surface of plastic debris, thus making plastic far more deadly in the ocean than it would be on land. Hydrophobic contaminants are also known to bioaccumulate in fatty tissues, biomagnifying up the food chain and putting pressure on apex predators. Some plastic additives are known to disrupt the endocrine system when consumed, others can suppress the immune system or decrease reproductive rates. Floating debris can also absorb persistent organic pollutants from seawater, including PCBs, DDT and PAHs. Aside from toxic effects, when ingested some of these are mistaken by the animal brain for estradiol, causing hormone disruption in the affected wildlife.

iv. Toxins

Apart from plastics, there are particular problems with other toxins that do not disintegrate rapidly in the marine environment. Examples of persistent toxins are PCBs, DDT, TBT, pesticides, furans, dioxins, phenols and radioactive waste. Heavy metals are metallic chemical elements that have a relatively high density and are toxic or poisonous at low concentrations. Examples are mercury, lead, nickel, arsenic and cadmium. Such toxins can accumulate in the tissues of many species of aquatic life in a process called bioaccumulation. They are also known to accumulate in benthic environments, such as estuaries and bay muds: a geological record of human activities of the last century.

v. Underwater noise

Marine life can be susceptible to noise or the sound pollution from sources such as passing ships, oil exploration seismic surveys, and naval low-frequency active sonar. Sound travels more rapidly and over larger distances in the sea than in the atmosphere. Marine animals, such as cetaceans, often have weak eyesight, and live in a world largely defined by acoustic information. This applies also to many deeper sea fish, who live in a world of darkness. Between 1950 and 1975, ambient noise in the ocean increased by about ten decibels (that is a tenfold increase).

Noise also makes species communicate louder, which is called the Lombard vocal response. Whale songs are longer when submarine-detectors are on. If creatures don't "speak" loud enough, their voice can be masked by anthropogenic sounds. These unheard voices might be warnings, finding of prey, or preparations of net-bubbling. When one species begins speaking louder, it will mask other species voices, causing the whole ecosystem to eventually speak louder.

Mitigation

Much anthropogenic pollution ends up in the ocean. The 2011 edition of the United Nations Environment Programme Year Book identifies as the main emerging environmental issues the loss to the oceans of massive amounts of phosphorus, "a valuable fertilizer needed to feed a growing global population", and the impact billions of pieces of plastic waste are having globally on the health of marine environments. Bjorn Jennssen (2003) notes in his article, "Anthropogenic pollution may reduce biodiversity and productivity of marine ecosystems, resulting in reduction and depletion of human marine food resources". There are two ways the overall level of this pollution can be mitigated: either the human population is reduced, or a way is found to reduce the ecological footprint left behind by the average human. If the second way is not adopted, then the first way may be imposed as world ecosystems falter.

The second way is for humans, individually, to pollute less. That requires social and political will, together with a shift in awareness so more people respect the environment and are less disposed to abuse it. At an operational level, regulations, and international government participation is needed. It is often very difficult to regulate marine pollution because pollution spreads over international barriers, thus making regulations hard to create as well as enforce.

Without appropriate awareness of marine pollution, the necessary global will to effectively address the issues may prove inadequate. Balanced information on the sources and harmful effects of marine pollution need to become part of general public awareness, and ongoing research is required to fully establish, and keep current, the scope of the issues. As expressed in Daoji and Dag's research, one of the reasons why environmental concern is lacking among the Chinese is because the public awareness is low and therefore should be targeted. Likewise, regulation, based upon such in-depth research should be employed. In California, such regulations have already been put in place to protect Californian coastal waters from agricultural runoff. This includes the California Water Code, as well as several voluntary programs. Similarly, in India, several tactics have been employed that help reduce marine pollution, however, they do not significantly target the problem. In Chennai, sewage has been dumped further into open waters. Due to the mass of waste being deposited, open-ocean is best for diluting, and dispersing pollutants, thus making them less harmful to marine ecosystems.

d. Noise Pollution

Most of us are very used to the sounds we hear in everyday life. Loud music, the television, people talking on their phone, the traffic and even pets barking in the middle of the night. All of these have become a part of the urban culture and rarely disturb us. However, when the sound of the television keeps you from sleeping all night or the traffic starts to give you a headache, it stops becoming just noise and start turning into noise pollution. For many of us, the concept of pollution is limited to nature and resources. However, noise that tends to disrupt the natural rhythm of life makes for one solid pollutant.

By definition, noise pollution takes place when there is either excessive amount of noise or an unpleasant sound that causes temporary disruption in the natural balance. This definition is usually applicable to sounds or noises that are

unnatural in either their volume or their production. Our environment is such that it has become difficult to escape noise. Even electrical appliances at home have a constant hum or beeping sound. By and large, lack of urban planning increases the exposure to unwanted sounds. This is why understanding noise pollution is necessary to curb it in time.

Causes of Noise Pollution

1. **Industrialization:** Most of the industries use big machines which are capable of producing large amount of noise. Apart from that, various equipments like compressors, generators, exhaust fans, grinding mills also participate in producing big noise. Therefore, you must have seen workers in these factories and industries wearing ear plugs to minimize the effect of noise.
2. **Poor Urban Planning:** In most of the developing countries, poor urban planning also play a vital role. Congested houses, large families sharing small space, fight over parking, frequent fights over basic amenities leads to noise pollution which may disrupt the environment of society.
3. **Social Events:** Noise is at its peak in most of the social events. Whether it is marriage, parties, pub, disc or place of worship, people normally flout rules set by the local administration and create nuisance in the area. People play songs on full volume and dance till midnight which makes the condition of people living nearby pretty worse. In markets, you can see people selling clothes via making loud noise to attract the attention of people.
4. **Transportation:** Large number of vehicles on roads, aeroplanes flying over houses, underground trains produce heavy noise and people get it difficult to get accustomed to that. The high noise leads to a situation wherein a normal person lose the ability to hear properly.
5. **Construction Activities:** Under construction activities like mining, construction of bridges, dams, buildings, stations, roads, flyovers take place in almost every part of the world. These construction activities take place everyday as we need more buildings, bridges to accommodate more people and to reduce traffic congestion. The down point is that these construction equipments are too noisy.
6. **Household Chores:** We people are surrounded by gadgets and use them extensively in our daily life. Gadgets like TV, mobile , mixer grinder, pressure cooker, vacuum cleaners , washing machine and dryer, cooler, air conditioners are minor contributors to the amount of noise that is produced but it affects the quality of life of your neighborhood in a bad way.

While this form of pollution may seem harmless, it in fact has far reaching consequences. The adverse effects on the health of the environment are quite severe. Not only is the local wildlife affected by the pollution, humans also face a number of problems due to it.

Effects of Noise Pollution

1. **Hearing Problems:** Any unwanted sound that our ears have not been built to filter can cause problems within the body. Our ears can take in a certain range of sounds without getting damaged. Man made noises such as jackhammers, horns, machinery, airplanes and even vehicles can be too loud for our hearing range. Constant exposure to loud levels of noise can easily result in the damage of our ear drums and loss of hearing. It also reduces our sensitivity to sounds that our ears pick up unconsciously to regulate our body's rhythm.
2. **Health Issues:** Excessive noise pollution in working areas such as offices, construction sites, bars and even in our homes can influence psychological health. Studies show that the occurrence of aggressive behavior, disturbance of sleep, constant stress, fatigue and hypertension can be linked to excessive noise levels. These in turn can cause more severe and chronic health issues later in life.
3. **Sleeping Disorders:** Loud noise can certainly hamper your sleeping pattern and may lead to irritation and uncomfortable situations. Without a good night sleep, it may lead to problems related to fatigue and your performance may go down in office as well as at home. It is therefore recommended to take a sound sleep to give your body proper rest.
4. **Cardiovascular Issues:** Blood pressure levels, cardio-vascular disease and stress related heart problems are on the rise. Studies suggest that high intensity noise causes high blood

pressure and increases heart beat rate as it disrupts the normal blood flow. Bringing them to a manageable level depends on our understanding noise pollution and how we tackle it.

5. **Trouble Communicating:** High decibel noise can put trouble and may not allow two people to communicate freely. This may lead to misunderstanding and you may get difficult understanding the other person. Constant sharp noise can give you severe headache and disturb your emotional balance.
6. **Effect on Wildlife:** Wildlife faces far more problems than humans because noise pollution since they are more dependent on sound. Animals develop a better sense of hearing than us since their survival depends on it. The ill effects of excessive noise begin at home. Pets react more aggressively in households where there is constant noise.

They become disoriented more easily and face many behavioral problems. In nature, animals may suffer from hearing loss, which makes them easy prey and leads to dwindling populations. Others become inefficient at hunting, disturbing the balance of the eco-system.

Species that depend on mating calls to reproduce are often unable to hear these calls due to excessive man made noise. As a result, they are unable to reproduce and cause declining populations. Others require sound waves to echo-locate and find their way when migrating. Disturbing their sound signals means they get lost easily and do not migrate when they should. To cope up with the increasing sound around them, animals are becoming louder, which may further add to the pollution levels. This is why understanding noise pollution can help us lower the impact it has on the environment.

As of now, there do not exist many solutions to reduce sound pollution. On a personal level, everybody can help reducing the noise in their homes by lowering the volume of the radio, music system and the television. Listening to music without headphones is also a good step forward. Removal of public loudspeakers is another way in which the pollution can be countered.

As is controlling the sound levels in clubs, bars, parties and discos. Better urban planning can help in creating 'No-Noise' zones, where honking and industrial noise are not tolerated. It is only when our understanding noise pollution is complete, can we take steps to eradicate it completely.

Mitigation

Roadway noise can be reduced by the use of noise barriers, limitation of vehicle speeds, alteration of roadway surface texture, limitation of heavy vehicles, use of traffic controls that smooth vehicle flow to reduce braking and acceleration, and tire design. An important factor in applying these strategies is a computer model for roadway noise, that is capable of addressing local topography, meteorology, traffic operations, and hypothetical mitigation. Costs of building-in mitigation can be modest, provided these solutions are sought in the planning stage of a roadway project.

Aircraft noise can be reduced by using quieter jet engines. Altering flight paths and time of day runway has benefitted residents near airports.

Industrial noise has been addressed since the 1930s via redesign of industrial equipment, shock mounted assemblies and physical barriers in the workplace. In recent years, Buy Quiet programs and initiatives have arisen in an effort to combat occupational noise exposures. These programs promote the purchase of quieter tools and equipment and encourage manufacturers to design quieter equipment.

e. Thermal Pollution

When someone thinks of pollution, the idea of thermal pollution often doesn't come to mind. People will first think of things like carbon emissions, personal pollution and waste, and a variety of other changing factors. However, thermal pollution is a real and persistent problem in our modern society. In layman's terms, thermal pollution is when an industry or other human-made organization takes in water from a natural source and either cools it down or heats it up. They then eject that water back into the natural resource, which changes the oxygen levels and can have disastrous effects on local ecosystems and communities.

Thermal pollution is defined as sudden increase or decrease in temperature of a natural body of water which may be ocean, lake, river or pond by human influence. This normally occurs when a plant or facility takes in water from a natural resource and puts it back with an altered

temperature. Usually, these facilities use it as a cooling method for their machinery or to help better produce their products.

Plants that produce different products or waste water facilities are often the culprits of this massive exodus of thermal pollution. In order to properly control and maintain thermal pollution, humans and governments have been taking many steps to effectively manage how plants are able to use the water. However, the effects are still lasting today.

Causes of Thermal Pollution

1. **Water as Cooling Agent in Power, Manufacturing and Industrial plants:** Production and Manufacturing plants are biggest source of thermal pollution. These plants draw water from nearby source to keep machines cool and then release back to the source with higher temperature. When heated water returns to the river or ocean, the water temperature rises sharply. When oxygen levels are altered in the water, this can also degrade the quality and longevity of life in wildlife that lives underwater. This process can also wipe away streamside vegetation, which constantly depends on constant levels of oxygen and temperature. By altering these natural environments, industries are essentially helping decrease the quality of life for these marines based life forms and can ultimately destroy habitats if they are not controlled and careful about their practices.
2. **Soil Erosion:** Soil erosion is another major factor that causes thermal pollution. Consistent soil erosion causes water bodies to rise, making them more exposed to sunlight. The high temperature could prove fatal for aquatic biomes as it may give rise to anaerobic conditions.
3. **Deforestation:** Trees and plants prevent sunlight from falling directly on lakes, ponds or rivers. When deforestation takes place, these water bodies are directly exposed to sunlight, thus absorbing more heat and raising its temperature. Deforestation is also a main cause of the higher concentrations of greenhouse gases i.e. global warming in the atmosphere.
4. **Runoff from Paved Surfaces:** Urban runoff discharged to surface waters from paved surfaces like roads and parking lots can make water warmer. During summer seasons, the pavement gets quite hot, which creates warm runoff that gets into the sewer systems and water bodies.
5. **Natural Causes:** Natural causes like volcanoes and geothermal activity under the oceans and seas can trigger warm lava to raise the temperature of water bodies. Lightening can also introduce massive amount of heat into the oceans. This means that the overall temperature of the water source will rise, having significant impacts on the environment.

Effects of Thermal Pollution

Among recognized scientists and scholars, there are generally two schools of thought when it comes to the effects of thermal pollution. Some lean on the side of the negatives of this pollution on marine ecosystems and how it is detrimental to positive environmental practices. However, some lean towards the side that without these industries operating the way they do, then some of the most basic parts of human life would be completely obsolete. Waste water would not be able to be properly maintained, we would have no industries that could produce the goods we need, and so on. The effects of thermal pollution on ecosystems, however, greatly outweigh the benefits that industries have by participating in the act.

1. **Decrease in DO (Dissolved Oxygen) Levels:** The warm temperature reduces the levels of DO (Dissolved Oxygen) in water. The warm water holds relatively less oxygen than cold water. The decrease in DO can create suffocation for plants and animals such as fish, amphibians and copepods, which may give rise to anaerobic conditions. Warmer water allows algae to flourish on surface of water and over the long term growing algae can decrease oxygen levels in the water.
2. **Increase in Toxins:** With the constant flow of high temperature discharge from industries, there is a huge increase in toxins that are being regurgitated into the natural body of water. These toxins may contain chemicals or radiation that may have harsh impact on the local ecology and make them susceptible to various diseases.
3. **Loss of Biodiversity:** A dent in the biological activity in the water may cause significant loss of biodiversity. Changes in the environment

may cause certain species of organisms to shift their base to some other place while their could be significant number of species that may shift in because of warmer waters. Organisms that can adapt easily may have an advantage over organisms that are not used to the warmer temperatures.

4. Ecological Impact: A sudden thermal shock can result in mass killings of fish, insects, plants or amphibians. Hotter water may prove favorable for some species while it could be lethal for other species. Small water temperature increases the level of activity while higher temperature decreases the level of activity. Many aquatic species are sensitive to small temperature changes such as one degree Celsius that can cause significant changes in organism metabolism and other adverse cellular biology effects.
5. Affects Reproductive Systems: A significant halt in the reproduction of marine wildlife (although this may be true, reproduction can still occur between fish – but the likelihood of defects in newborns is significantly higher) can happen due to increasing temperatures as reproduction can happen with in certain range of temperature. Excessive temperature can cause the release of immature eggs or can prevent normal development of certain eggs.
6. Increases Metabolic Rate: Thermal pollution increases the metabolic rate of organisms as increasing enzyme activity occurs that causes organisms to consume more food than what is normally required, if their environment were not changed. It disrupts the stability of food chain and alter the balance of species composition.
7. Migration: The warm water can also cause particular species of organisms to migrate to suitable environment that would cater to its requirements for survival. This can result in loss for those species that depend on them for their daily food as their food chain is interrupted.

Above all else, the most important thing to consider is that the effects of thermal pollution greatly outweighs the human need for it to be done. Plants and industries have been able to find successful ways around thermal pollution, but many of them are not practicing it because it's simply easier to work from the traditional model. If we want to promote the thriving environment that surrounds marine biology, then the attitude around thermal pollution needs to take a drastic turn. By being aware of the causes and effects, you can have a significant impact on how these plants choose to operate and you can opt to make change.

Control of thermal pollution

i. Industrial wastewater

In the developed copuntries, about 75 to 82 percent of thermal pollution is generated by power plants. The remainder is from industrial sources such as petroleum refineries, pulp and paper mills, chemical plants, steel mills and smelters. Heated water from these sources may be controlled with:

- cooling ponds, man-made bodies of water designed for cooling by evaporation, convection, and radiation
- cooling towers, which transfer waste heat to the atmosphere through evaporation and/or heat transfer
- cogeneration, a process where waste heat is recycled for domestic and/or industrial heating purposes.

Some facilities use once-through cooling (OTC) systems which do not reduce temperature as effectively as the above systems. For example, the Potrero Generating Station in San Francisco (closed in 2011), used OTC and discharged water to San Francisco Bay approximately 10°C (20°F) above the ambient bay temperature.

ii. Urban runoff

During warm weather, urban runoff can have significant thermal impacts on small streams, as stormwater passes over hot parking lots, roads and sidewalks. Stormwater management facilities that absorb runoff or direct it into groundwater, such as bioretention systems and infiltration basins, can reduce these thermal effects. Retention basins (ponds) tend to be less effective at reducing temperature, as the water may be heated by the sun before being discharged to a receiving stream.

f. Nuclear hazards

Radionuclides are elements (uranium 235, uranium 283, thorium 232, potassium 40, radium 226, carbon 14 etc.) with unstable atomic nuclei and on decomposition release ionizing radiations in the form of alpha, beta and gamma rays.

Out of the known 450 radioisotopes only some are of environmental concern like strontium 90, tritium, plutonium 239, argon 41, cobalt 60, cesium 137, iodine 131, krypton 85 etc. These can be both beneficial and harmful, depending on the way in which they are used.

We routinely use X-rays to examine bones for fractures, treat cancer with radiation and diagnose diseases with the help of radioactive isotopes. About 17% of the electrical energy generated in the world comes from nuclear power plants.

Radioactive substances when released into the environment are either dispersed or become concentrated in living organisms through the food chain. Other than naturally occurring radioisotopes, significant amounts are generated by human activity, including the operation of nuclear power plants, the manufacture of nuclear weapons, and atomic bomb testing.

For example, strontium 90 behaves like calcium and is easily deposited and replaces calcium in the bone tissues. It could be passed to human beings through ingestion of strontium-contaminated milk. Again another example is tritium, which is radioactive hydrogen.

The amount of tritium released from nuclear power plants to the atmosphere have reached as high as tens of thousands of curies in one year, and releases to bodies of water have measured as high as tens of millions of picocuries per litre. The U.S. Environmental Protection Agency standard for permissible levels of tritium in drinking water is 20,000 picocuries per litre.

Nuclear power plants routinely and accidentally release tritium into the air and water. Tritium has a half-life of 12.3 years and emits radioactive beta particles. Once tritium is inhaled or swallowed, its beta particles can bombard cells causing a mutation.

Few occupations that involve radioactive exposures are uranium mineworkers, radium watch dial painters, technical staff at nuclear power plants, etc. Exposure to radioactive and nuclear hazards has been clinically proven to cause cancer, mutations and teratogenesis (Teratogenesis is a prenatal toxicity characterized by structural or functional defects in the developing embryo or fetus).

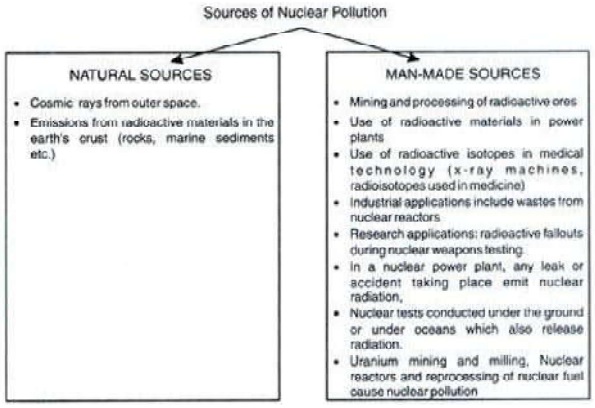
Nuclear hazard effects can be either initial or residual. Initial effects occur in the immediate area of explosion and are hazardous immediately after the explosion where as the residual effects can last for days or years and cause death. The principal initial effects are blast and radiation.

Blast causes damage to lungs, ruptures eardrums, collapses structures and causes immediate death or injury. Thermal Radiation is the heat and light radiation, which a nuclear explosion's fireball emits producing extensive fires, skin burns, and flash blindness. Nuclear radiation consists of intense gamma rays and neutrons produced during the first minute after the explosion.

This radiation causes extensive damage to cells throughout the body. Radiation damage may cause headaches, nausea, vomiting, diarrhea, and even death, depending on the radiation dose received.

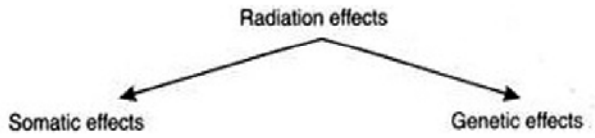
Sources of Nuclear Pollution

The sources of radioactivity include both natural and manmade.



Effects of Nuclear Pollution

Studies have shown that the health effects due to radiation are dependent on the level of dose, kind of radiation, duration of exposure and types of cells irradiated. Radiation effects can be somatic or genetic.



1. Somatic effects

Somatic effects the function of cells and organs. It causes damages to cell membranes, mitochondria and cell nuclei resulting in abnormal cell functions, cell division, growth and death.

2. Genetic effects

Genetic effects the future generations. Radiations can cause mutations, which are changes in genetic makeup of cells. These effects are mainly due to the damages to DNA molecules. People suffer from blood cancer and bone cancer if exposed to doses around 100 to 1000 roentgens. Instantaneous deaths on exposure in the event if disasters are many.

Management of Radioactive Waste

a. The radioactive waste which comes out from industry, nuclear reactors should be stored and allowed to decay either naturally in closed drums or in very large underground air tight cemented tanks (Delay and Decay).
b. The intermediate radioactive waste should be disposed off into the environment after diluting it with some inert materials (Dilute and Disperse)
c. Now-a-days small quantities of high activity wastes are converted into solids such as concrete and then it is buried underground or sea. (Concentrate and contain)

Control Measures

a. Laboratory generated nuclear wastes should be disposed off safely and scientifically.
b. Nuclear power plants should be located in areas after careful study of the geology of the area, tectonic activity and meeting other established conditions.
c. Appropriate protection against occupational exposure.
d. Leakage of radioactive elements from nuclear reactors, careless use of radioactive elements as fuel and careless handling of radioactive isotopes must be prevented.
e. Safety measure against accidental release of radioactive elements must be ensured in nuclear plants.
f. Unless absolutely necessary, one should not frequently go for diagnosis by x-rays.
g. Regular monitoring of the presence of radioactive substance in high risk area should be ensured.

Among the many options for waste disposal, the scientists prefer to bury the waste in hundreds of meters deep in the earth's crust is considered to be the best safety long term option.

Solid Waste Management: Causes, Effects and Control Measures of Urban and Industrial Waste

Around most towns and cities in India the approach roads are littered with multi-coloured plastic bags and other garbage. Waste is also burnt to reduce its volume. Modern methods of disposal such as incineration and the development of sanitary landfills, etc. are now attempting to solve these problems. Lack of space for dumping solid waste has become a serious problem in several cities and towns all over the world. Dumping and burning wastes is not an acceptable practice today from either an environmental or a health perspective. Today disposal of solid waste should be part of an integrated waste management plan. The method of collection, processing, resource recovery and the final disposal should mesh with one another to achieve a common objective.

Characteristics of municipal solid waste

Solid wastes are grouped or classified in several different ways. These different classifications are necessary to address the complex challenges of solid waste management in an effective manner. The term municipal solid waste (MSW) is generally used to describe most of the non-hazardous solid waste from a city, town or village that requires routine collection and transport to a processing or disposal site. Sources of MSW include private homes, commercial establishments and institutions as well as industrial facilities. However MSW does not include wastes from industrial processes, construction and demolition debris, sewage sludge, mining wastes or agricultural wastes.

Municipal solid waste contains a wide variety of materials. It can contain food waste such as vegetable and meat material, leftover food, egg shells, etc which is classified as wet garbage as well as paper, plastic, tetrapacks, plastic cans, newspaper, glass bottles, cardboard boxes, aluminum foil, metal items, wood pieces, etc. which is classified as dry garbage.

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

1. Source reduction
2. Recycling
3. Disposal

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

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

The problems associated with recycling are either technical or economical. Plastics are difficult to recycle because of the different types of polymer resins used in their production. Since each type has its own chemical makeup different plastics cannot be recycled together. Thus separation of different plastics before recycling is necessary. Similarly in recycled paper the fibers are weakened and it is difficult to control the colour of the recycled product. Recycled paper is banned for use in food containers to prevent the possibility of contamination. It very often costs less to transport raw paper pulp than scrap paper. Collection, sorting and transport account for about 90 percent of the cost of paper recycling. The processes of pulping, deinking and screening wastepaper are generally more expensive than making paper from virgin wood or cellulose fibers. Very often thus recycled paper is more expensive than virgin paper. However as technology improves the cost will come down.

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

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

The problem with older landfills are associated with groundwater pollution. Pollutants seeping out from the bottom of a sanitary landfill (leachates) very often percolate down to the groundwater aquifer no matter how thick the underlying soil layer. Today it is essential to have suitable bottom liners and leachate collection systems along with the installation of monitoring systems to detect groundwater pollution. The organic material in the buried solid waste will decompose due to the action of microorganisms. At first the waste decomposes aerobically until the oxygen that was present in the freshly placed fill is used up by the aerobic microorganisms. The anerobes take over producing methane which is poisonous and highly explosive when mixed with air in concentrations between 5 and 15 percent. The movement of gas can be controlled by providing impermeable barriers in the landfill. A venting system to collect the blocked gas and vent it to the surface where it can be safely diluted and dispersed into the atmosphere is thus a necessary component of the design of sanitary landfills.

Even though landfilling is an economic alternative for solid waste disposal, it has become increasingly difficult to find suitable landfilling sites that are within economic hauling distance and very often citizens do not want landfills in their vicinity. Another reason is that no matter how well engineered the design and operation may be, there is always the danger of some environmental damage in the form of leakage of leachates.

Incineration

Incineration is the process of burning municipal solid waste in a properly designed furnace under suitable temperature and operating conditions.

Incineration is a chemical process in which the combustible portion of the waste is combined with oxygen forming carbon dioxide and water, which are released into the atmosphere. This chemical reaction called oxidation results in the release of heat. For complete oxidation the waste must be mixed with appropriate volumes of air at a temperature of about 815o C for about one hour. Incineration can reduce the municipal solid waste by about 90 percent in volume and 75 percent in weight. The risks of incineration however involve airquality problems and toxicity and disposal of the fly and bottom ash produced during the incineration process. Fly ash consists of finely divided particulate matter, including cinders, mineral dust and soot. Most of the incinerator ash is bottom ash while the remainder is fly ash. The possible presence of heavy metals in incinerator ash can be harmful. Thus toxic products and materials containing heavy metals (for example batteries and plastics) should be segregated. Thus extensive air pollution control equipment and high-level technical supervision and skilled employees for proper operation and maintenance is required.

Thus while sanitary landfills and incinerators have their own advantages and disadvantages, the most effective method of solid waste management is source reduction and recycling.

Vermi – Composting

Nature has perfect solutions for managing the waste it creates, if left undisturbed. The biogeochemical cycles are designed to clear the waste material produced by animals and plants. We can mimic the same methods that are present in nature. All dead and dry leaves and twigs decompose and are broken down by organisms such as worms and insects, and is finally broken down by bacteria and fungi, to form a dark rich soil-like material called compost.

These organisms in the soil use the organic material as food, which provides them with nutrients for their growth and activities. These nutrients are returned to the soil to be used again by trees and other plants. This process recycles nutrients in nature.

This soil can be used as a manure for farms and gardens.

Hazardous wastes

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

Environmental problems and health risks caused by hazardous wastes

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

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

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

Mercury occurs in several different forms. Mercury is used in the production of chlorine. It is also used as a catalyst in the production of some plastics. Industrial processes such as the production of chlorine and plastics are responsible

for most of the environmental damage resulting from mercury. Our body has a limited ability to eliminate mercury. In the food web mercury becomes more concentrated as it is taken up by various organisms. In an aquatic environment, mercury can be absorbed by the plankton which are then consumed by fish. In addition, fish take up mercury through their gills and by eating other fish contaminated with mercury. Generally older the fish greater is the mercury concentration in its body. Birds that eat the fish concentrate even more mercury in their bodies. It is a cumulative poison (it builds up in the body over long periods of time) and is known to cause brain damage.

Thousands of chemicals are used in industry everyday. When used incorrectly or inappropriately they can become health hazards. PCBs (Polychlorinated biphenyls) are resistant to fire and do not conduct electricity very well which makes them excellent materials for several industrial purposes. Rainwater can wash PCBs out of disposal areas in dumps and landfills thus contaminating water. PCBs do not break down very rapidly in the environment and thus retain their toxic characteristics. They cause long term exposure problems to both humans and wildlife. PCBs are concentrated in the kidneys and liver and thus cause damage. They cause reproductive failure in birds and mammals.

Vinyl chloride is a chemical that is widely used in the manufacture of plastic. Usually people are only exposed to high levels of vinyl chloride if they work with it or near it but exposure can also occur from vinyl chloride gas leaks. After a long continuous exposure (one to three years) in humans, vinyl chloride can cause deafness, vision problems, circulation disorders and bone deformities. Vinyl chloride can also cause birth defects.

It is essential to substitute the use of PCBs and vinyl chloride with chemicals that are less toxic. Polyvinyl chloride use can be lowered by reducing our use of plastics. Thus by reducing waste, encouraging recycling and using products that are well made and durable we can greatly reduce our consumption of these chemicals thus curtailing our exposure to these substances.

We may not realize it but many household chemicals can be quite toxic to humans as well as wildlife. Most of the dangerous substances in our homes are found in various kinds of cleaners, solvents and products used in automotive care. When these products are used incorrectly they have the potential to be harmful.

Today the most common methods for disposing off hazardous wastes are land disposal and incineration. In countries where there is abundant land available for disposal for example, North America land disposal is the most widely used method. In countries like Europe and Japan where land is not readily available and is expensive, incineration is the preferred method for disposal. In spite of strong laws however illegal dumping of these wastes continues. Hazardous waste management must move beyond burying and burning. Industries need to be encouraged to generate less hazardous waste in their manufacturing processes. Although toxic wastes cannot be entirely eliminated, technologies are available for minimizing, recycling and treating wastes. An informed public can also contribute in a big way towards this end. It is essential for us to understand the ill effects of chemical substances so that we can make informed decisions about its use. We might decide that the benefits of the use of a toxic substance do not outweigh the risks and choose not to use it at all or we may decide that it is acceptable to use a substance under certain specific circumstances where it is adequately controlled and exposure to toxic levels is prevented.

DISASTER MANAGEMENT

The Indian subcontinent is very vulnerable to droughts, floods, cyclones, earthquakes, landslides, avalanches and forest fires. Among the 36 states and Union territories in the country, 22 are prone to disasters.

Among all the disasters that occur in the country, floods are the most frequently occurring natural disasters, due to the irregularities of the Indian monsoon. About 75 percent of the annual rainfall in India is concentrated in three to four months of the monsoon season. As a result there is a very heavy discharge from the rivers during this period causing widespread floods. Approximately 40 million hectares of land in the country has been identified as being prone to floods. Major floods are mainly caused in the Ganga-Brahmaputra-Meghna basin which carries 60 percent of the total river flow of our country.

India has a long coastline of 5700 kms, which is exposed to tropical cyclones arising in the Bay of Bengal and the Arabian sea. The Indian Ocean is one of the six major cyclone prone regions of the world. In India, cyclones occur usually between April and May and also between October and December. The eastern coastline is more prone to cyclones as it is hit by about 80 percent of the total cyclones generated in the region.

Droughts are a perennial feature in some states of India. Sixteen percent of the country's total area is drought prone. Drought is a significant environmental problem as it is caused by a lower than average rainfall over a long period of time. Most of the drought prone areas identified by the Government lie in the arid and semi-arid areas of the country.

Earthquakes are considered to be one of the most destructive natural hazards. The impact of this phenomenon occurs with so little warning that it is almost impossible to make preparations against damages and collapse of buildings. About 50 to 60 percent of India is vulnerable to seismic activity of varying intensities. Most of the vulnerable areas are located in the Himalayan and sub-Himalayan regions.

From management to mitigation of disasters

Till very recently the approach towards dealing with natural disasters has been post disaster management involving problems such as evacuation, warnings, communications, search and rescue, fire-fighting, medical and psychiatric assistance, provision of relief, shelter, etc. After the initial trauma and the occurrence of the natural disaster is over and reconstruction and rehabilitation is done by people, NGOs and the Government, its memories are relegated to history.

It is evident today that human activities are responsible for accelerating the frequency and severity of natural disasters. Natural occurrences such as floods, earthquakes, cyclones, etc. will always occur. They are a part of the environment that we live in. However destruction from natural hazards can be minimized by the presence of a well functioning warning system combined with preparedness on part of the community that will be affected. Thus though traditionally disaster management consisted primarily of reactive mechanisms, the past few years have witnessed a gradual shift towards a more proactive, mitigation based approach.

Disaster management is a multidisciplinary area in which a wide range of issues that range from forecasting, warning, evacuation, search and rescue, relief, reconstruction and rehabilitation are included. It is also multi-sectoral as it involves administrators, scientists, planners, volunteers and communities. These roles and activities span the pre-disaster, during disaster and post disaster plans. Since their activities are complementary as well as supplementary to each other there is a critical need for coordinating these activities.

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

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

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

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

scientific, private sector, NGOs and the community.

The main elements of a mitigation strategy are as follows:

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

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

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

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

Public awareness and training

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

Institutional mechanisms

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

Incentives and resources for mitigation

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

Land use planning and regulations

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

Hazard resistant design and construction

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

Structural and Constructional reinforcement of existing buildings

It is also possible to reduce the vulnerability of existing buildings through minor adaptations or alterations thereby ensuring their safety. This can be done by insertion of walls on the outside of the building, buttresses, walls in the interior of the building, portico fill-in-walls, specially anchored frames, covering of columns and beams, construction of new frame system, placing residential electrical equipment above flood level, designing water storage tanks to be able to withstand cyclonic winds, earthquakes and floods, etc.

Floods and mitigation measures

The lower plain regions of India in particular Bihar, Uttar Pradesh and West Bengal in respect of the Ganga and Assam in respect of the Brahmaputra suffer from the adverse effects of floods every year. The Ganga Brahmaputra basin receives maximum run off within the three monsoon months. Based on hydrological studies carried out, it is estimated that only 18 percent of the rainwater can be stored in dams, reservoirs, etc. while 82 percent of the rainwater flows through rivers ultimately into the sea. Floods are therefore a recurring phenomenon in our country.

Floods can be caused by natural, ecological or anthropogenic factors either individually or as a combined result. Anthropogenic activities such as deforestation and shifting cultivation can also contribute to floods. Forests on the hill slopes normally exert a sponge effect soaking up the abundant rainfall and storing it before releasing it in small amounts over a period of time. However when the forests are cleared the rivers turn muddy and swollen during the wet monsoon season and run dry later on in the year during the drier periods. An increasing proportion of the rainfall is therefore released shortly after precipitation in the form of floods.

The mitigation measures for floods include both structural and non-structural measures. The structural measures include:

- Reservoirs for impounding monsoon flows to be released in a regulated manner after the peak flood flow passes.
- Prevention of over-bank spilling by the construction of embankments and floodwalls.
- Improvement of flow conditions in the channel and anti-erosion measures.
- Improved drainage.

The non-structural measures include:

- Flood plain management such as Flood Plain Zoning and Flood Proofing including Disaster Preparedness
- Maintaining wetlands
- Flood forecasting and warning services
- Disaster relief, flood fighting and public health measures
- Flood insurance

Earthquakes and mitigation measures

It has been several years since the earthquake struck Gujarat on January 26, 2001. In these years rehabilitation has been done on a massive scale. Gujarat's experience has taught that building shelters with less vulnerability to earthquakes should also take into consideration the specific needs of the victims instead of being a top down approach. The role of NGOs in this is very important. Their strength lies in their manpower, informality in operations and valuable human resources. Their ability to reach out to the community and sensitivity to local traditions is an asset in such situations. A report on the various initiatives in Gujarat reported in Down to Earth (Vol 12, No. 2) by Mihir Bhatt throws light on the various developments that have taken place after the earthquake. According to the report the initiatives of the International Fund for Agriculture Development in supporting the Self Employed Women's Association and the Government's initiative in community based livelihood security for earthquakes and drought victims have the potential to shape future disaster response and development projects in Gujarat. Similarly the Gujarat Woman's Economic Development Corporation initiative in reviving women's businesses after the calamity also provides many practical lessons in regenerating local economies and artisan markets. This project supported by the Asian Development Bank, puts premium on investments in income generation and asset building after a natural disaster. The farming kits provided to affected farmers by

Gujarat's agriculture ministry is also showing promising results after two seasons. The author however states that coordination between Government, local NGOs and local community initiatives both for rescue as well as rehabilitation needs to be strengthened as this can cause delays, overlaps and waste of relief material and efforts.

Cyclones and mitigation measures

Tropical cyclones are the worst natural hazards in the tropics. They are large revolving vortices in the atmosphere extending horizontally from 150 to1000 km and vertically from the surface to 12 to 14 km. These are intense low-pressure areas. Strong winds spiraling anti clockwise in the Northern Hemisphere blow around the cyclone center at the lower level. At the higher levels the sense of rotation is just opposite to that at the lower level. They generally move 300 to 5000 km per day over the ocean. While moving over the ocean they pick up energy from the warm water of the ocean and some of them grow into a devastating intensity. On an average about 5 to 6 tropical cyclones form in the Bay of Bengal and the Arabian Sea every year out of which 2 to 3 may be severe. More cyclones form in the Bay of Bengal than in the Arabian Sea. The main dangers from cyclones are very strong winds, torrential rains and high storm tides. Most of the causalities are caused by coastal inundation by storm tides. This is often followed by heavy rainfall and floods. Storm surges cause the greatest destruction.

Although one cannot control cyclones, the effects of cyclones can be mitigated through effective and efficient mitigation policies and strategies. A brief description of the same is given below.

Installation of early warning systems: Such systems fitted along the coastlines can greatly assist forecasting techniques thus helping in early evacuation of people in the storm surge areas.

Developing communication infrastructure: Communication plays a vital role in cyclone disaster mitigation and yet this is one of the first services that gets disrupted during cyclones. Amateur Radio has today emerged as a second line unconventional communications systems and is an important tool for disaster mitigation.

Developing shelter belts: Shelter belts with plantations of trees can act as effective wind and tide breakers. Apart from acting as effective windbreakers and protecting soil crops from being damaged they prevent soil erosion.

Developing community cyclone shelters: Cyclone shelters at strategic locations can help minimizing the loss of human life. In the normal course these shelters can be used as public utility buildings.

Construction of permanent houses: There is a need to build appropriately designed concrete houses that can withstand high winds and tidal waves.

Training and education: Public awareness programs that inform the population about their response to cyclone warnings and preparedness can go a long way in reducing causalities.

Landuse control and settlement planning: No residential and industrial units should be ideally permitted in the coastal belt of 5 km from the sea as it is the most vulnerable belt. No further growth of settlements in this region should allowed. Major settlements and other important establishments should be located beyond 10 km from the sea.

Landslides and mitigation measures

Landslides are recurring phenomena in the Himalayan region. In the recent years however intensive construction activity and the destabilizing forces of nature have aggravated the problem. Landslides occur as a result of changes on a slope, sudden or gradual, either in its composition, structure, hydrology or vegetation. The changes can be due to geology, climate, weathering, land-use and earthquakes.

A significant reduction in the hazards caused by landslides can be achieved by preventing the exposure of population and facilities to landslides and by physically controlling the landslides. Developmental programs that involve modification of the topography, exploitation of natural resources and change in the balance load on the ground should not be permitted. Some critical measures that could be undertaken to prevent further landslides are drainage measures, erosion control measures such a bamboo check dams, terracing, jute and coir netting and rockfall control measures such as grass plantation, vegetated dry masonry wall, retaining wall and most importantly preventing deforestation and improving afforestation.

Disasters cannot be totally prevented. However early warning systems, careful planning and preparedness on part of the vulnerable community would help in minimizing the loss of life and property due to these disasters.

■■■

BIODIVERSITY

CHAPTER

It is now widely recognized that climate change and biodiversity are interconnected. Biodiversity is affected by climate change, with negative consequences for human well-being, but biodiversity, through the ecosystem services it supports, also makes an important contribution to both climate-change mitigation and adaptation. Consequently, conserving and sustainably managing biodiversity is critical to addressing climate change.

CLIMATE CHANGE

In the atmosphere, gases such as water vapour, carbon dioxide, ozone, and methane act like the glass roof of a greenhouse by trapping heat and warming the planet. These gases are called greenhouse gases. The natural levels of these gases are being supplemented by emissions resulting from human activities, such as the burning of fossil fuels, farming activities and land-use changes. As a result, the Earth's surface and lower atmosphere are warming, and this rise in temperature is accompanied by many other changes.

Rising levels of greenhouse gases are already changing the climate. According to the Intergovernmental Panel on Climate Change (IPCC) Working Group I (WGI) Fourth Assessment Report, from 1850 to 2005, the average global temperature increased by about 0.76ºC and global mean sea level rose by 12 to 22 cm during the last century. These changes are affecting the entire world, from low-lying islands in the tropics to the vast polar regions.

Climate change predictions are not encouraging; according to the IPCC WGI Fourth Assessment Report, a further increase in temperatures of 1.4°C to 5.8°C by 2100 is projected. Predicted impacts associated with such temperature increase include: a further rise in global mean sea level, changes in precipitation patterns, and more people at risk from dangerous "vector-borne diseases" such as malaria.

Vulnerability of biodiversity to the impacts of climate change

The present global biota has been affected by fluctuating Pleistocene (last 1.8 million years) concentrations of atmospheric carbon dioxide, temperature, precipitation, and has coped through evolutionary changes, and the adoption of natural adaptive strategies. Such climate changes, however, occurred over an extended period of time in a landscape that was not as fragmented as it is today and with little or no additional pressure from human activities. Habitat fragmentation has confined many species to relatively small areas within their previous ranges, resulting in reduced genetic variability. Warming beyond the ceiling of temperatures reached during the Pleistocene will stress ecosystems and their biodiversity far beyond the levels imposed by the global climatic change that occurred in the recent evolutionary past.

Current rates and magnitude of species extinction far exceed normal background rates. Human activities have already resulted in the loss of biodiversity and thus may have affected goods and services crucial for human well-being. The rate and magnitude of climate change induced by increased greenhouse gases emissions has and will continue to affect biodiversity either directly or in combination with other drivers of change.

Links between biodiversity and climate change

There is ample evidence that climate change affects biodiversity. According to the Millennium Ecosystem Assessment, climate change is likely to become one of the most significant drivers of biodiversity loss by the end of the century. Climate change is already forcing biodiversity to adapt either through shifting habitat, changing life cycles, or the development of new physical traits.

Conserving natural terrestrial, freshwater and marine ecosystems and restoring degraded ecosystems (including their genetic and species diversity) is essential for the overall goals of both

the Convention on Biological Diversity and the United Nations Framework Convention on Climate Change because ecosystems play a key role in the global carbon cycle and in adapting to climate change, while also providing a wide range of ecosystem services that are essential for human well-being and the achievement of the Millennium Development Goals.

Biodiversity can support efforts to reduce the negative effects of climate change. Conserved or restored habitats can remove carbon dioxide from the atmosphere, thus helping to address climate change by storing carbon (for example, reducing emissions from deforestation and forest degradation). Moreover, conserving in-tact ecosystems, such as mangroves, for example, can help reduce the disastrous impacts of climate change such as flooding and storm surges.

Ecosystem-based Adaptation

Ecosystem-based adaptation, which integrates the use of biodiversity and ecosystem services into an overall adaptation strategy, can be cost-effective and generate social, economic and cultural co-benefits and contribute to the conservation of biodiversity.

Conservation and management strategies that maintain and restore biodiversity can be expected to reduce some of the negative impacts from climate change; however, there are rates and magnitude of climate change for which natural adaptation will become increasingly difficult. Options to increase the adaptive capacity of species and ecosystems in the face of accelerating climate change include:

- Reducing non-climatic stresses, such as pollution, over-exploitation, habitat loss and fragmentation and invasive alien species.
- Wider adoption of conservation and sustainable use practices including through the strengthening of protected area networks.
- Facilitating adaptive management through strengthening monitoring and evaluation systems.

Ecosystem-based adaptation uses biodiversity and ecosystem services in an overall adaptation strategy. It includes the sustainable management, conservation and restoration of ecosystems to provide services that help people adapt to the adverse effects of climate change. Examples of ecosystem-based adaptation activities include:

- Coastal defence through the maintenance and/or restoration of mangroves and other coastal wetlands to reduce coastal flooding and coastal erosion.
- Sustainable management of upland wetlands and floodplains for maintenance of water flow and quality.
- Conservation and restoration of forests to stabilize land slopes and regulate water flows.
- Establishment of diverse agroforestry systems to cope with increased risk from changed climatic conditions.
- Conservation of agrobiodiversity to provide specific gene pools for crop and livestock adaptation to climate change.

DEFINITION

From the above discussion we got to know, why the issue of biodiversity is so important but a basic question remains unanswered. What is biodiversity?

"Biodiversity" is most commonly used to replace the more clearly defined and long established terms, species diversity and species richness. Biologists most often define biodiversity as the "totality of genes, species, and ecosystems of a region". An advantage of this definition is that it seems to describe most circumstances and presents a unified view of the traditional types of biological variety previously identified:

- taxonomic diversity (usually measured at the species diversity level)
- ecological diversity often viewed from the perspective of ecosystem diversity
- morphological diversity which stems from genetic diversity
- molecular Diversity

The 1992 United Nations Earth Summit defined "biological diversity" as "the variability among living organisms from all sources, including, 'inter alia', terrestrial, marine, and other aquatic ecosystems, and the ecological complexes of which they are part: this includes diversity within species,

between species and of ecosystems". This definition is used in the United Nations Convention on Biological Diversity.

Genetically biodiversity can be defined as the diversity of alleles, genes, and organisms. They study processes such as mutation and gene transfer that drive evolution.

Structure of Biodiversity protection mechanism

The idea of protection of biodiversity started gaining currency in the 1980s. It took a concrete shape with the Earth Summit of 1992.

Earth Summit

The Earth Summit in Rio de Janeiro was unprecedented for a UN conference, in terms of both its size and the scope of its concerns. Twenty years after the first global environment conference, the UN sought to help Governments rethink economic development and find ways to halt the destruction of irreplaceable natural resources and pollution of the planet. Hundreds of thousands of people from all walks of life were drawn into the Rio process. They persuaded their leaders to go to Rio and join other nations in making the difficult decisions needed to ensure a healthy planet for generations to come.

The Summit's message — that nothing less than a transformation of our attitudes and behaviour would bring about the necessary changes — was transmitted by almost 10,000 on-site journalists and heard by millions around the world. The message reflected the complexity of the problems facing us: that poverty as well as excessive consumption by affluent populations place damaging stress on the environment. Governments recognized the need to redirect international and national plans and policies to ensure that all economic decisions fully took into account any environmental impact. And the message has produced results, making eco-efficiency a guiding principle for business and governments alike.

- Patterns of production — particularly the production of toxic components, such as lead in gasoline, or poisonous waste — are being scrutinized in a systematic manner by the UN and Governments alike;
- Alternative sources of energy are being sought to replace the use of fossil fuels which are linked to global climate change;
- New reliance on public transportation systems is being emphasized in order to reduce vehicle emissions, congestion in cities and the health problems caused by polluted air and smog;
- There is much greater awareness of and concern over the growing scarcity of water.

The two-week Earth Summit was the climax of a process, begun in December 1989, of planning, education and negotiations among all Member States of the United Nations, leading to the adoption of Agenda 21, a wide-ranging blueprint for action to achieve sustainable development worldwide. At its close, Maurice Strong, the Conference Secretary-General, called the Summit a "historic moment for humanity". Although Agenda 21 had been weakened by compromise and negotiation, he said, it was still the most comprehensive and, if implemented, effective programme of action ever sanctioned by the international community. Today, efforts to ensure its proper implementation continue, and they will be reviewed by the UN General Assembly at a special session to be held in June 1997.

The Earth Summit influenced all subsequent UN conferences, which have examined the relationship between human rights, population, social development, women and human settlements — and the need for environmentally sustainable development. The World Conference on Human Rights, held in Vienna in 1993, for example, underscored the right of people to a healthy environment and the right to development, controversial demands that had met with resistance from some Member States until Rio.

Convention on Biological Diversity

The Convention on Biological Diversity (CBD), known informally as the Biodiversity Convention, is a multilateral treaty. The Convention has three main goals:

1. conservation of biological diversity (or biodiversity);
2. sustainable use of its components; and
3. fair and equitable sharing of benefits arising from genetic resources

In other words, its objective is to develop national strategies for the conservation and sustainable use of biological diversity. It is often seen as the key document regarding sustainable development.

The Convention was opened for signature at the Earth Summit in Rio de Janeiro on 5 June 1992 and entered into force on 29 December 1993.

The convention recognized for the first time in international law that the conservation of biological diversity is "a common concern of humankind" and is an integral part of the development process. The agreement covers all ecosystems, species, and genetic resources. It links traditional conservation efforts to the economic goal of using biological resources sustainably. It sets principles for the fair and equitable sharing of the benefits arising from the use of genetic resources, notably those destined for commercial use. It also covers the rapidly expanding field of biotechnology through its Cartagena Protocol on Biosafety, addressing technology development and transfer, benefit-sharing and biosafety issues. Importantly, the Convention is legally binding; countries that join it ('Parties') are obliged to implement its provisions.

The convention reminds decision-makers that natural resources are not infinite and sets out a philosophy of sustainable use. While past conservation efforts were aimed at protecting particular species and habitats, the Convention recognizes that ecosystems, species and genes must be used for the benefit of humans. However, this should be done in a way and at a rate that does not lead to the long-term decline of biological diversity.

The convention also offers decision-makers guidance based on the precautionary principle that where there is a threat of significant reduction or loss of biological diversity, lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimize such a threat. The Convention acknowledges that substantial investments are required to conserve biological diversity. It argues, however, that conservation will bring us significant environmental, economic and social benefits in return.

Some of the many issues dealt with under the convention include:

- Measures and incentives for the conservation and sustainable use of biological diversity.
- Regulated access to genetic resources and traditional knowledge, including Prior Informed Consent of the party providing resources.
- Sharing, in a fair and equitable way, the results of research and development and the benefits arising from the commercial and other utilization of genetic resources with the Contracting Party providing such resources (governments and/or local communities that provided the traditional knowledge or biodiversity resources utilized).
- Access to and transfer of technology, including biotechnology, to the governments and/or local communities that provided traditional knowledge and/or biodiversity resources.
- Technical and scientific cooperation.
- Coordination of a global directory of taxonomic expertise (Global Taxonomy Initiative).
- Impact assessment.
- Education and public awareness.
- Provision of financial resources.
- National reporting on efforts to implement treaty commitments.

International bodies established by the convention

Conference of the parties: The convention's governing body is the Conference of the parties (COP), consisting of all governments (and regional economic integration organizations) that have ratified the treaty. This ultimate authority reviews progress under the Convention, identifies new priorities, and sets work plans for members. The COP can also make amendments to the Convention, create expert advisory bodies, review progress reports by member nations, and collaborate with other international organizations and agreements.

The Conference of the Parties uses expertise and support from several other bodies that are established by the Convention. In addition to committees or mechanisms established on an ad hoc basis, two main organs are:

Secretariat: The CBD Secretariat. Based in Montreal, it operates under the United Nations Environment Programme. Its main functions are to organize meetings, draft documents, assist member governments in the implementation of the

programme of work, coordinate with other international organizations, and collect and disseminate information.

Subsidiary body for Scientific, Technical and Technological Advice (SBSTTA): The Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA). The SBSTTA is a committee composed of experts from member governments competent in relevant fields. It plays a key role in making recommendations to the COP on scientific and technical issues. 13th Meeting of the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA-13) held from 18 to 22 February 2008 in the Food and Agriculture Organization at Rome, Italy. SBSTTA-13 delegates met in the Committee of the Whole in the morning to finalize and adopt recommendations on the in-depth reviews of the work programmes on agricultural and forest biodiversity and SBSTTA's modus operandi for the consideration of new and emerging issues. The closing plenary convened in the afternoon to adopt recommendations on inland waters biodiversity, marine biodiversity, invasive alien species and biodiversity and climate change.

List of Conference of Parties

S.No.	Year	CoP	Location	Remarks
1	1994	COP_1	Nassau, Bahamas.	
2	1995	COP_2	Jakarta, Indonesia.	
3	1996	COP_3	Buenos Aires, Argentina.	
4	1998	COP_4	Bratislava, Slovakia.	
5	1999	$EXCOP_1$	Cartagena, Colombia.	
6	2000	COP_5	Nairobi, Kenya.	
7	2002	COP_6	The Hague, Netherlands.	
8	2004	COP_7	Kuala Lumpur, Malaysia.	
9	2006	COP_8	Curitiba, Brazil.	
10	2008	COP_9	Bonn, Germany.	
11	2010	COP_{10}	Nagoya, Japan.	
12	2012	COP_{11}	Hyderabad, India	India successfully hosted the eleventh meeting of the Conference of the Parties (COP 11) to the Convention on Biological Diversity (CBD) held from 8-19 October 2012, in Hyderabad, India, following the sixth Meeting of the Parties to the Cartagena Protocol on Biosafety (COP/MOP 6). The event provided India with an opportunity to consolidate, scale-up and showcase our strengths on biodiversity. The meetings were presided over by the Minister for Environment and Forests, India as the President of CoP-11. The High Level Segment was inaugurated by the Prime Minister of India. The Prime Minister at CoP-11 launched the 'Hyderabad Pledge', wherein he announced that the Government of India has decided to earmark a sum of US $ 50 million during India's Presidency of CoP to strengthen institutional mechanism, enhance the technical and human capabilities for biodiversity conservation in India, and to promote similar capacity building in other developing countries.
13	2014	COP 12	Pyeongchang, Republic of Korea	Under the theme, "Biodiversity for Sustainable Development," thousands of representatives of governments, NGOs, indigenous peoples, scientists and the private sector gathered in Pyeongchang, Republic of Korea for the 12th meeting of the Conference of the Parties to the Convention on Biological Diversity(COP 12)From October 6–17, 2014, parties discussed the implementation of the Strategic Plan for Biodiversity 2011-2020 and its Aichi Biodiversity Targets, which are to be achieved by the end of this decade. The results of Global Biodiversity Outlook 4, the flagship assessment report of the CBD informed the discussions.The conference gave a mid-term evaluation to the UN Decade on Biodiversity (2011-2020) initiative, which aims to promote the conservation and sustainable use of nature.At the end of the meeting, participants adopted the "Pyeongchang Road Map," which addresses ways to achieve biodiversity through technology cooperation, funding and strengthening the capacity of developing countries.

2016 COP 13: The thirteenth ordinary meeting of the parties to the convention takes will take place December 2016 in Los Cabos, Baja California South, Mexico

National Biodiversity Strategies and Action Plans (NBSAP)

"National Biodiversity Strategies and Action Plans (NBSAPs) are the principal instruments for implementing the Convention at the national level (Article 6). The Convention requires countries to prepare a national biodiversity strategy (or equivalent instrument) and to ensure that this strategy is mainstreamed into the planning and activities of all those sectors whose activities can have an impact (positive and negative) on biodiversity. 173 Parties have developed NBSAPs in line with Article 6."

For example, the United Kingdom, New Zealand and Tanzania have carried out elaborate responses to conserve individual species and specific habitats. The United States of America, a signatory who has not yet ratified the treaty, has produced one of the most thorough implementation programs through species Recovery Programs and other mechanisms long in place in the USA for species conservation.

Singapore has also established a detailed National Biodiversity Strategy and Action Plan. The National Biodiversity Centre of Singapore represents Singapore in the Convention for Biological Diversity.

National Reports

In accordance with Article 26 of the Convention, Parties prepare national reports on the status of implementation of the Convention.

AICHI TARGETS

The tenth meeting of the Conference of the Parties, held from 18 to 29 October 2010, in Nagoya, Aichi Prefecture, Japan, adopted a revised and updated strategic plan. This plan provides an overarching framework on biodiversity, not only for the biodiversity-related conventions, but for the entire United Nations system and all other partners engaged in biodiversity management and policy development.

This plan is divided into two parts, the midterm plan for 2050 and short term plan till 2020. The short term plan is officially known as "Strategic Plan for Biodiversity 2011-2020". It is a ten-year framework for action by all countries to save biodiversity. This short term plan provide a set of 20 ambitious yet achievable targets, collectively known as the Aichi Targets. These are:-

Strategic Goal A: Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society

Target 1

By 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably.

Target 2

By 2020, at the latest, biodiversity values have been integrated into national and local development and poverty reduction strategies and planning processes and are being incorporated into national accounting, as appropriate, and reporting systems.

Target 3

By 2020, at the latest, incentives, including subsidies, harmful to biodiversity are eliminated, phased out or reformed in order to minimize or avoid negative impacts, and positive incentives for the conservation and sustainable use of biodiversity are developed and applied, consistent and in harmony with the Convention and other relevant international obligations, taking into account national socio economic conditions.

Target 4

By 2020, at the latest, Governments, business and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits.

Strategic Goal B: Reduce the direct pressures on biodiversity and promote sustainable use

Target 5

By 2020, the rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced.

Target 6

By 2020 all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches,

so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits.

Target 7

By 2020 areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity.

Target 8

By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity.

Target 9

By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment.

Target 10

By 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning.

Strategic Goal C: To improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity

Target 11

By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.

Target 12

By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.

Target 13

By 2020, the genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio-economically as well as culturally valuable species, is maintained, and strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversity.

Strategic Goal D: Enhance the benefits to all from biodiversity and ecosystem services

Target 14

By 2020, ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable.

Target 15

By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15 per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification.

Target 16

By 2015, the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization is in force and operational, consistent with national legislation.

Strategic Goal E: Enhance implementation through participatory planning, knowledge management and capacity building

Target 17

By 2015 each Party has developed, adopted as a policy instrument, and has commenced implementing an effective, participatory and updated national biodiversity strategy and action plan.

Target 18

By 2020, the traditional knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use

of biodiversity, and their customary use of biological resources, are respected, subject to national legislation and relevant international obligations, and fully integrated and reflected in the implementation of the Convention with the full and effective participation of indigenous and local communities, at all relevant levels.

Target 19

By 2020, knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied.

Target 20

By 2020, at the latest, the mobilization of financial resources for effectively implementing the Strategic Plan for Biodiversity 2011-2020 from all sources, and in accordance with the consolidated and agreed process in the Strategy for Resource Mobilization, should increase substantially from the current levels. This target will be subject to changes contingent to resource needs assessments to be developed and reported by Parties.

CARTAGENA PROTOCOL ON BIOSAFETY

The Cartagena Protocol on Biosafety to the Convention on Biological Diversity is an international agreement which aims to ensure the safe handling, transport and use of living modified organisms (LMOs) resulting from modern biotechnology that may have adverse effects on biological diversity, taking also into account risks to human health. On 29 January 2000, the Conference of the Parties to the Convention on Biological Diversity adopted a supplementary agreement to the Convention known as the Cartagena Protocol on Biosafety. The Protocol seeks to protect biological diversity from the potential risks posed by living modified organisms resulting from modern biotechnology. It establishes an advance informed agreement (AIA) procedure for ensuring that countries are provided with the information necessary to make informed decisions before agreeing to the import of such organisms into their territory. The Protocol contains reference to a precautionary approach and reaffirms the precaution language in Principle 15 of the Rio Declaration on Environment and Development. The Protocol also establishes a Biosafety Clearing-House to facilitate the exchange of information on living modified organisms and to assist countries in the implementation of the Protocol.

The Open-ended Ad Hoc Working Group on Biosafety held six meetings between July 1996 and February 1999. At its conclusion, the Working Group submitted a draft text of the Protocol, as well as the outstanding concerns of the Parties, for consideration by Conference of the Parties at its first extraordinary meeting, convened for the purpose of adopting a protocol on biosafety to the Convention on Biological Diversity. In accordance, the first extraordinary meeting of the Conference of the Parties was opened on 22 February 1999, in Cartagena, Colombia. The Conference of the Parties was not able to finalize its work in the time available. As a result, the Conference of the Parties suspended its first extraordinary meeting and agreed that it should be reconvened as soon as possible and in any event no later than the fifth meeting of the Conference of the Parties.

The resumed session took place in Montreal from 24 to 29 January 2000 and was preceded by regional and interregional informal consultations from 20 to 23 January 2000 at the same venue. On 29 January 2000, the Conference of the Parties, adopted the Cartagena Protocol on Biosafety to the Convention on Biological Diversity and approved interim arrangements pending its entry into force. It established an open-ended ad hoc Intergovernmental Committee for the Cartagena Protocol on Biosafety (ICCP) with a mandate to undertake the preparations necessary for the first meeting of the Parties to the Protocol.

Living modified organisms (LMOs)

The protocol defines a 'living modified organism' as any living organism that possesses a novel combination of genetic material obtained through the use of modern biotechnology, and 'living organism' means any biological entity capable of transferring or replicating genetic material, including sterile organisms, viruses and viroids. 'Modern biotechnology' is defined in the Protocol to mean the application of in vitro nucleic acid techniques, or fusion of cells beyond the taxonomic family, that overcome natural

physiological reproductive or recombination barriers and are not techniques used in traditional breeding and selection. 'Living modified organism (LMO) Products' are defined as processed material that are of living modified organism origin, containing detectable novel combinations of replicable genetic material obtained through the use of modern biotechnology (for instance, flour from GM maize). 'Living modified organism intended for direct use as food or feed, or for processing (LMO-FFP)' are agricultural commodities from GM crops. Overall the term 'living modified organisms' is equivalent to genetically modified organism – the Protocol did not make any distinction between these terms and did not use the term 'genetically modified organism.'

Precautionary approach

One of the outcomes of the United Nations Conference on Environment and Development (also known as the Earth Summit) held in Rio de Janeiro, Brazil, in June 1992, was the adoption of the Rio Declaration on Environment and Development, which contains 27 principles to underpin sustainable development. Commonly known as the precautionary principle, Principle 15 states that "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

Elements of the precautionary approach are reflected in a number of the provisions of the Protocol, such as:

- The preamble, reaffirming "the precautionary approach contained in Principle 15 of the Rio Declaration on environment and Development";
- Article 1, indicating that the objective of the Protocol is "in accordance with the precautionary approach contained in Principle 15 of the Rio Declaration on Environment and Development";
- Article 10.6 and 11.8, which states "Lack of scientific certainty due to insufficient relevant scientific information and knowledge regarding the extent of the potential adverse effects of an LMO on biodiversity, taking into account risks to human health, shall not prevent a Party of import from taking a decision, as appropriate, with regard to the import of the LMO in question, in order to avoid or minimize such potential adverse effects."; and
- Annex III on risk assessment, which notes that "Lack of scientific knowledge or scientific consensus should not necessarily be interpreted as indicating a particular level of risk, an absence of risk, or an acceptable risk."

Application

The Protocol applies to the transboundary movement, transit, handling and use of all living modified organisms that may have adverse effects on the conservation and sustainable use of biological diversity, taking also into account risks to human health.

Parties and non-parties

The governing body of the Protocol is called the Conference of the Parties to the Convention serving as the meeting of the Parties to the Protocol (also the COP-MOP). The main function of this body is to review the implementation of the Protocol and make decisions necessary to promote its effective operation. Decisions under the Protocol can only be taken by Parties to the Protocol. Parties to the Convention that are not Parties to the Protocol may only participate as observers in the proceedings of meetings of the COP-MOP.

The Protocol addresses the obligations of Parties in relation to the transboundary movements of LMOs to and from non-Parties to the Protocol. The transboundary movements between Parties and non-Parties must be carried out in a manner that is consistent with the objective of the Protocol. Parties are required to encourage non-Parties to adhere to the Protocol and to contribute information to the Biosafety Clearing-House.

Features

The Protocol promotes biosafety by establishing rules and procedures for the safe transfer, handling,

and use of LMOs, with specific focus on transboundary movements of LMOs. It features a set of procedures including one for LMOs that are to be intentionally introduced into the environment called the advance informed agreement procedure, and one for LMOs that are intended to be used directly as food or feed or for processing. Parties to the Protocol must ensure that LMOs are handled, packaged and transported under conditions of safety. Furthermore, the shipment of LMOs subject to transboundary movement must be accompanied by appropriate documentation specifying, among other things, identity of LMOs and contact point for further information. These procedures and requirements are designed to provide importing Parties with the necessary information needed for making informed decisions about whether or not to accept LMO imports and for handling them in a safe manner.

The Party of import makes its decisions in accordance with scientifically sound risk assessments. The Protocol sets out principles and methodologies on how to conduct a risk assessment. In case of insufficient relevant scientific information and knowledge, the Party of import may use precaution in making their decisions on import. Parties may also take into account, consistent with their international obligations, socio-economic considerations in reaching decisions on import of LMOs.

Parties must also adopt measures for managing any risks identified by the risk assessment, and they must take necessary steps in the event of accidental release of LMOs.

To facilitate its implementation, the Protocol establishes a Biosafety Clearing-House for Parties to exchange information, and contains a number of important provisions, including capacity-building, a financial mechanism, compliance procedures, and requirements for public awareness and participation.

NAGOYA PROTOCOL ON GENETIC RESOURCES

The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity is an international agreement which aims at sharing the benefits arising from the utilization of genetic resources in a fair and equitable way, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding, thereby contributing to the conservation of biological diversity and the sustainable use of its components. It was adopted by the Conference of the Parties to the Convention on Biological Diversity at its tenth meeting on 29 October 2010 in Nagoya, Japan. The Nagoya Protocol entered into force on 12 October 2014, 90 days after the date of deposit of the fiftieth instrument of ratification.

The Nagoya Protocol is intended to create greater legal certainty and transparency for both providers and users of genetic resources by:

- Establishing more predictable conditions for access to genetic resources.
- Helping to ensure benefit-sharing when genetic resources leave the contracting party providing the genetic resources

By helping to ensure benefit-sharing, the Protocol creates incentives to conserve and sustainably use genetic resources, and therefore enhances the contribution of biodiversity to development and human well-being.

Scope

The Nagoya Protocol applies to genetic resources that are covered by the CBD, and to the benefits arising from their utilization. The Protocol also covers traditional knowledge associated with genetic resources that are covered by the CBD and the benefits arising from its utilization.

Obligations

The Nagoya Protocol sets out obligations for its contracting parties to take measures in relation to access to genetic resources, benefit-sharing and compliance.

1. Access obligations

Domestic-level access measures are to:

- Create legal certainty, clarity and transparency
- Provide fair and non-arbitrary rules and procedures
- Establish clear rules and procedures for prior informed consent and mutually agreed terms

- Provide for issuance of a permit or equivalent when access is granted
- Create conditions to promote and encourage research contributing to biodiversity conservation and sustainable use
- Pay due regard to cases of present or imminent emergencies that threaten human, animal or plant health
- Consider the importance of genetic resources for food and agriculture for food security

2. Benefit-sharing obligations

Domestic-level benefit-sharing measures are to provide for the fair and equitable sharing of benefits arising from the utilization of genetic resources with the contracting party providing genetic resources. Utilization includes research and development on the genetic or biochemical composition of genetic resources, as well as subsequent applications and commercialization. Sharing is subject to mutually agreed terms. Benefits may be monetary or non-monetary such as royalties and the sharing of research results.

3. Compliance obligations

Specific obligations to support compliance with the domestic legislation or regulatory requirements of the contracting party providing genetic resources, and contractual obligations reflected in mutually agreed terms, are a significant innovation of the Nagoya Protocol. Contracting Parties are to:

- Take measures providing that genetic resources utilized within their jurisdiction have been accessed in accordance with prior informed consent, and that mutually agreed terms have been established, as required by another contracting party
- Cooperate in cases of alleged violation of another contracting party's requirements
- Encourage contractual provisions on dispute resolution in mutually agreed terms
- Ensure an opportunity is available to seek recourse under their legal systems when disputes arise from mutually agreed terms
- Take measures regarding access to justice
- Take measures to monitor the utilization of genetic resources after they leave a country including by designating effective checkpoints at any stage of the value-chain: research, development, innovation, pre-commercialization or commercialization

Implementation

The Nagoya Protocol's success will require effective implementation at the domestic level. A range of tools and mechanisms provided by the Nagoya Protocol will assist contracting Parties including:

- Establishing national focal points (NFPs) and competent national authorities (CNAs) to serve as contact points for information, grant access or cooperate on issues of compliance
- An Access and Benefit-sharing Clearing-House to share information, such as domestic regulatory ABS requirements or information on NFPs and CNAs
- Capacity-building to support key aspects of implementation.

Based on a country's self-assessment of national needs and priorities, capacity-building may help to:

- Develop domestic ABS legislation to implement the Nagoya Protocol
- Negotiate MAT
- Develop in-country research capability and institutions
- Raise awareness
- Transfer technology
- Target financial support for capacity-building and development initiatives through the GEF.

■■■

INITIATIVES TAKEN IN INDIA

CHAPTER

India, a megadiverse nation, is one of the richest nations in terms of biological diversity. India owes this to its position in the tropical and subtropical latitudes. India has a great diversity of natural ecosystems ranging from the cold and high Himalayan regions to the sea coasts; from the wet north-eastern green forests to the dry northwestern arid deserts; with different types of forests, wetlands, islands and the oceans. India consists of fertile river plains and high plateaus and several major rivers, including the Ganges, Brahmaputra and Indus. The diverse physical features and climatic situations have formed ecological habitats like forests, grasslands, wetlands, coastal and marine ecosystems and desert ecosystems, which harbour and sustain immense biodiversity. The country is also one of the 12 primary centres of origin of cultivated plants and domesticated animals.

WHY CONSERVE BIODIVERSITY?

As we all know by now, Biodiversity is essential for maintaining the ecological functions, including stabilizing of the water cycle, maintenance and replenishment of soil fertility, pollination and cross-fertilization of crops and other vegetation, protection against soil erosion and stability of food producing and other ecosystems. Conservation of biological diversity leads to conservation of essential ecological diversity to preserve the continuity of food chains.

Biodiversity provides the base for the livelihoods, cultures and economies of several hundred millions of people, including farmers, fisher folk, forest dwellers and artisans. It provides raw material for a diverse medicinal and health care systems. It also provides the genetic base for the continuous up-gradation of agriculture, fisheries, and for critical discoveries in scientific, industrial and other sectors. The rapid erosion of biodiversity in the last few decades has impacted on the health of the land, waterbodies and people.

Biodiversity is a wealth to which no value can be put. In the final analysis, the very survival of the human race is dependent on conservation of biodiversity. It is evident that this invaluable heritage is being destroyed at an alarming rate due to several reasons. Measures are being taken up at national and international levels to address this issue. The Earth Summit produced a plan of action on a number of issues (Agenda 21) including conservation of biodiversity during the 21st century. Conservation and sustainable use of biological resources based on local knowledge systems and practices is ingrained in Indian ethos. The country has a number of alternative medicines, like Ayurveda, Unani, Siddha and Homeopathic systems which are predominantly based on plant based raw materials in most of their preparations and formulations. Herbal preparations for various purposes including pharmaceutical and cosmetic form part of traditional biodiversity uses in India.

However, before we start with the discussion on biodiversity conservation in India, we would be discussing a few basic concepts associated with Biodiversity Conservation. These are:-

a. Biodiversity Hotspot

A biodiversity hotspot is a biogeographic region with a significant reservoir of biodiversity that is under threat from humans. To qualify as a biodiversity hotspot, a region must meet two strict criteria: it must contain at least 0.5% or 1,500 species of vascular plants as endemics, and it has to have lost at least 70% of its primary vegetation. Around the world, 34 areas qualify under this definition, with nine other possible candidates. These sites support nearly 60% of the world's plant, bird, mammal, reptile, and amphibian species, with a very high share of endemic species.

Hotspot conservation initiatives

Only a small percentage of the total land area within biodiversity hotspots is now protected. Several international organizations are working in many ways to conserve biodiversity hotspots.

- Critical Ecosystem Partnership Fund (CEPF) is a global program that provides funding and technical assistance to nongovernmental organizations and participation to protect the Earth's richest regions of plant and animal diversity including: biodiversity hotspots, high-biodiversity wilderness areas and important marine regions. CI works in more than 40 countries on four continents, with headquarters near Washington, D.C.
- The World Wildlife Fund has derived a system called the "Global 200 Ecoregions", the aim of which is to select priority Ecoregions for conservation within each of 14 terrestrial, 3 freshwater, and 4 marine habitat types. They are chosen for their species richness, endemism, taxonomic uniqueness, unusual ecological or evolutionary phenomena, and global rarity. All biodiversity hotspots contain at least one Global 200 Ecoregion.
- Birdlife International has identified 218 "Endemic Bird Areas" (EBAs) each of which hold two or more bird species found nowhere else. Birdlife International has identified more than 11,000 Important Bird Areas all over the world.
- Plantlife International coordinates several the world aiming to identify Important Plant Areas.
- Alliance for Zero Extinction is an initiative of a large number of scientific organizations and conservation groups who co-operate to focus on the most threatened endemic species of the world. They have identified 595 sites, including a large number of Birdlife's Important Bird Areas.
- The National Geographic Society has prepared a world map of the hotspots and ArcView shapefile and metadata for the Biodiversity Hotspots including details of the individual endangered fauna in each hotspot, which is available from Conservation International.

Hotspots in India

India has been classified as one of the most biodiversity rich regions of the world. Four major regions of the country have been classified as Biodiversity Hotspot, these are:

1. The Himalayan Region
2. The Eastern Himalayas (This hotspot has nearly 163 globally threatened species including the One-horned Rhinoceros (Rhinoceros unicornis), the Wild Asian Water buffalo (Bubalus bubalis (Arnee)) and in all 45 mammals, 50 birds, 17 reptiles, 12 amphibians, 3 invertebrate and 36 plant species. The Relict Dragonfly (Epiophlebia laidlawi) is an endangered species found here with the only other species in the genus being found in Japan. The region is also home to the Himalayan Newt (Tylototriton verrucosus), the only salamander species found within Indian limits.)
3. The Nilgiri Region or Western Ghats (region harbors over 450 bird species, about 140 mammalian species, 260 reptiles and 175 amphibians.)
4. The Nicobar Islands Region (Part of Sunda Biodiversity Hotspot of South-East Asia)

But as we speak of diversity, it first starts with the human species. Arguably, only the continent of Africa exceeds the linguistic, genetic and cultural diversity of the nation of India. The country houses 1.2 billion people speaking 1652 languages and dialects, spread out over more than two thousand ethnicities and over every major religion.

From the above discussion we can understand the importance of Forest, Animal & Agricultural biodiversity. We will be discussing them one by one.

b. Forest biodiversity

Forests are biologically diverse systems, representing some of the richest biological areas on Earth. They offer a variety of habitats for plants, animals and micro-organisms. However, forest biodiversity is increasingly threatened as a result of deforestation, fragmentation, climate change and other stressors.

Tropical, temperate and boreal forests offer a diverse set of habitats for plants, animals and micro-organisms. Consequently forests hold the majority of the world's terrestrial species. However these biologically rich systems are increasingly threatened, largely as a result of human activity.

What is Forest Biological Diversity?

Forest biological diversity is a broad term that refers to all life forms found within forested areas and the ecological roles they perform. As such, forest biological diversity encompasses not just trees, but the multitude of plants, animals and micro-organisms that inhabit forest areas and their associated genetic diversity.

Forest biological diversity can be considered at different levels, including the ecosystem, landscapes, species, populations and genetics. Complex interactions can occur within and amongst these levels. In biologically diverse forests, this complexity allows organisms to adapt to continually changing environmental conditions and to maintain ecosystem functions.

The Conference of the Parties recognized that:

"Forest biological diversity results from evolutionary processes over thousands and even millions of years which, in themselves, are driven by ecological forces such as climate, fire, competition and disturbance. Furthermore, the diversity of forest ecosystems (in both physical and biological features) results in high levels of adaptation, a feature of forest ecosystems which is an integral component of their biological diversity. Within specific forest ecosystems, the maintenance of ecological processes is dependent upon the maintenance of their biological diversity."

However, in the last 8000 years about 45% of the Earth's original forest cover has disappeared, most of which was cleared during the past century. The Food and Agriculture Organization of the United Nations (FAO) recently estimated that about 13 million hectares of the world's forests are lost due to deforestation each year. The annual net loss of forest area between 2000 and 2005 was 7.3 million hectares (equivalent to the net loss of 0.18 percent of the world's forests).

The mechanisms that cause deforestation, fragmentation and degradation are varied and can be direct or indirect. However, the most important factors associated with the decline of forest biological diversity are of human origin. The conversion of forests to agricultural land, overgrazing, unmitigated shifting cultivation, unsustainable forest management, introduction of invasive alien plant and animal species, infrastructure development (e.g. road building, hydro-electrical development, urban sprawl), mining and oil exploitation, anthropogenic forest fires, pollution, and climate change are all having negative impacts on forest biological diversity. And as forests are degraded, so too is biological diversity. This degradation lowers the resilience of forest ecosystems and makes it more difficult for them to cope with changing environmental conditions.

What Needs to be Done?

Forests have been on the international political agenda since the 1992 United Nations Conference on Environment and Development (UNCED), held in Rio De Janeiro, Brazil. As a result of the intensive negotiations during this meeting, governments agreed to the Non-legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of all Types of Forests, also known as the "Forest Principles."

Since this meeting, considerable progress has been made regarding forest biodiversity, with several international meetings being held and numerous processes being created. For example, the Ministerial Conference on the Protection of Forests in Europe (MCPFE) is a political initiative involving 40 European countries as well as the European Community. The MCPFE promotes the protection and sustainable management of forests in Europe.

Increasingly, much of the work on forest biological diversity is focusing on the creation and refinement of forest indicators. For example, in 1994 The Montréal Process, a Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests, was formed in Geneva, Switzerland. The Montréal Process promotes the development and implementation of internationally agreed criteria and indicators for the conservation and sustainable management of temperate and boreal forests. Indicators are important information tools as they allow for the assessment of the status and trends of forest resources globally as well as the 2010 Biodiversity Target. As such, indicators have come to be recognized as a vital component of sustainable forest management and, more recently, the ecosystem approach.

The issue of climate change has resulted in

considerable attention being devoted to forests. As forests act both as a carbon sink and are likely to be greatly affected by climate change, they have become a growing issue of consideration for many governments and organizations. You can read more about efforts to reduce emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries (REDD-plus) on the REDD-plus pages.

Given the importance of forests the Conference of the Parties decided at its sixth meeting in 2002 that an expanded programme of work on forest biological diversity was needed to address the issues confronting forest systems. The Secretariat of the Convention on Biological Diversity assists Parties in implementing this programme of work.

c. Animal Biodiversity

The biodiversity of the 35 or so animal species that have been domesticated for use in agriculture and food production is the primary biological capital for livestock development and is vital to food security and sustainable rural development. Many indigenous breeds, some of which are threatened with extinction, have characteristics such as resilience to climatic stress and resistance to diseases and parasites, which make them well adapted to local conditions, and which are of great potential importance to future livestock production.

Yet this resource is often neglected and poorly managed. Recent years have seen substantial erosion of domestic animal diversity – a trend that is likely to accelerate with the rapid changes currently affecting the livestock sector.

Livestock development in the twentieth century concentrated on a very small number of breeds worldwide, frequently without due consideration to the way in which production environments affect animals' ability to survive, produce and reproduce.

According to The State of the World's Animal Genetic Resources for Food and Agriculture (2007), 20 percent of documented livestock breeds are at risk of extinction: 1500 of the 7600 breeds around the globe may be lost forever in the near future.

d. Agricultural Biodiversity

Agricultural biodiversity is a broad term that includes all components of biological diversity of relevance to food and agriculture, and all components of biological diversity that constitute the agricultural ecosystems, also named agro-ecosystems: the variety and variability of animals, plants and micro-organisms, at the genetic, species and ecosystem levels, which are necessary to sustain key functions of the agro-ecosystem, its structure and processes.

Agricultural biodiversity is the outcome of the interactions among genetic resources, the environment and the management systems and practices used by farmers. This is the result of both natural selection and human inventive developed over millennia.

The following dimensions of agricultural biodiversity can be identified:

(1) Genetic resources for food and agriculture:

- Plant genetic resources, including crops, wild plants harvested and managed for food, trees on farms, pasture and rangeland species,
- Animal genetic resources, including domesticated animals, wild animals hunted for food, wild and farmed fish and other aquatic organisms,
- Microbial and fungal genetic resources.

These constitute the main units of production in agriculture, and include cultivated and domesticated species, managed wild plants and animals, as well as wild relatives of cultivated and domesticated species.

(2) Components of biodiversity that support ecosystem services upon which agriculture is based. These include a diverse range of organisms that contribute, at various scales to, inter alia, nutrient cycling, pest and disease regulation, pollination, pollution and sediment regulation, maintenance of the hydrological cycle, erosion control, and climate regulation and carbon sequestration.

(3) Abiotic factors, such as local climatic and chemical factors and the physical structure and functioning of ecosystems, which have a determining effect on agricultural biodiversity.

(4) Socio-economic and cultural dimensions. Agricultural biodiversity is largely shaped and maintained by human activities and management practices, and a large number of people depend on agricultural biodiversity for sustainable livelihoods. These dimensions include traditional and local knowledge of agricultural biodiversity, cultural factors and participatory processes, as well as tourism associated with agricultural landscapes.

Why is it Important?

Biodiversity and agriculture are strongly interdependent

Biodiversity is the basis of agriculture. It has enabled farming systems to evolve ever since agriculture was first developed some 10,000 years ago. Biodiversity is the origin of all species of crops and domesticated livestock and the variety within them. It is also the foundation of ecosystem services essential to sustain agriculture and human well-being. Today's crop and livestock biodiversity are the result of many thousands years of human intervention.

Biodiversity and agriculture are strongly interrelated because while biodiversity is critical for agriculture, agriculture can also contribute to conservation and sustainable use of biodiversity. Indeed, sustainable agriculture both promotes and is enhanced by biodiversity. Maintenance of this biodiversity is essential for the sustainable production of food and other agricultural products and the benefits these provide to humanity, including food security, nutrition and livelihoods.

Importance of agricultural biodiversity

Agricultural biodiversity provides humans with food and raw materials for goods - such as cotton for clothing, wood for shelter and fuel, plants and roots for medicines, and materials for biofuels - and with incomes and livelihoods, including those derived from subsistence farming. Agricultural biodiversity also performs ecosystem services such as soil and water conservation, maintenance of soil fertility and biota, and pollination, all of which are essential to human survival. In addition, genetic diversity of agricultural biodiversity provides species with the ability to adapt to changing environment and evolve, by increasing their tolerance to frost, high temperature, drought and water-logging, as well as their resistance to particular diseases, pests and parasites for example. This is particularly important regarding climate change. The evolution of biodiversity, and therefore both its and our survival, mainly depends on this genetic diversity.

The importance of agricultural biodiversity encompasses socio-cultural, economic and environmental elements. All domesticated crops and animals result from human management of biodiversity, which is constantly responding to new challenges to maintain and increase productivity under constantly varying conditions.

Special nature of agricultural biodiversity

The Conference of the Parties has recognized "the special nature of agricultural biodiversity, its distinctive features, and problems needing distinctive solutions". Indeed, several features set agricultural biodiversity apart other components of biodiversity:

- Agricultural biodiversity is essential to satisfy basic human needs for food and livelihood security.
- Agricultural biodiversity has been - and is still - shaped and developed through human activities and practices over generations. Farmers' communities play a key role as custodians and managers of agricultural biodiversity. This is why local and traditional knowledge and culture are considered as integral parts of agricultural biodiversity management.
- Because of the degree of human management, conservation of agricultural biodiversity in production systems is inherently linked to sustainable use.
- Nonetheless, much agricultural biodiversity is now conserved ex situ in gene banks or breeders' materials.
- For crops and domestic animals, diversity within species is at least as important as diversity between species and has been greatly expanded through agriculture.
- Many farming systems are based on alien crop species introduced from elsewhere; this creates a high degree of interdependence between countries for the genetic resources for food and agriculture.

- The interaction between the environment, genetic resources and management practices that occurs in situ within agro-ecosystems often contributes to maintaining a dynamic portfolio of agricultural biodiversity.

However, agriculture has to face two main challenges in relation with biodiversity:

- to sustain agricultural biodiversity and ecosystem services provided by, and necessary for, agriculture, and
- to mitigate the negative impacts of agricultural systems and practices on biodiversity which is not used directly whether in the same or other ecosystems.

To address these challenges, agriculture is required to take into account different drivers of change such as:

- indirect drivers, e.g. demography (and the expected major growth world population and food demand), economy (e.g. globalization, market, and trade forces), socio politics (e.g. consumption choices, and policy, institutional and legal frameworks), and science and technology;
- direct drivers, e.g. climate change, natural resource availability (in particular water), overuse of agricultural chemicals, land-use changes.

All these drivers contribute to the loss of biodiversity both in agricultural and other ecosystems, threatening human well-being.

However, agriculture has to face two main challenges in relation with biodiversity:

- to sustain agricultural biodiversity and ecosystem services provided by, and necessary for, agriculture, and
- to mitigate the negative impacts of agricultural systems and practices on biodiversity which is not used directly whether in the same or other ecosystems.

To address these challenges, agriculture is required to tabke into account different drivers of change such as:

- indirect drivers, e.g. demography (and the expected major growth world population and food demand), economy (e.g. globalization, market, and trade forces), socio politics (e.g. consumption choices, and policy, institutional and legal frameworks), and science and technology;
- direct drivers, e.g. climate change, natural resource availability (in particular water), overuse of agricultural chemicals, land-use changes.

All these drivers contribute to the loss of biodiversity both in agricultural and other ecosystems, threatening human well-being.

What Needs to be Done?

The CBD programme of work on agricultural biodiversity is designed to address these challenges. It is structured to take into account the different dimensions of agricultural biodiversity and is based on four elements:

- assessing the status and trends of the world's agricultural biodiversity, the underlying causes of change, and knowledge of management practices;
- identifying adaptive management techniques, practices and policies;
- building capacity, increasing awareness and promoting responsible action; and
- mainstreaming national plans and strategies for the conservation and sustainable use of agricultural biodiversity into relevant agriculture sectors.

In addition, three cross-cutting initiatives have been adopted under the programme of work to address specific issues:

- the International Initiative for the Conservation and Sustainable Use of Pollinators and its action plan
- the International Initiative for the Conservation and Sustainable Use of Soil Biodiversity and its framework for action; and
- the International Initiative on Biodiversity for Food and Nutrition and its framework.

The ecosystem approach is promoted as a tool to address multiple issues and objectives across cultural, socio-economic and environmental dimensions, resulting in balance between the production of food and the sustained delivery of other ecosystem services necessary to sustain human well-being.