ENVIRONMENT & ECOLOGY

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6th term 2
4. Air

Introduction

Air is present everywhere around us. We cannot see air. But we can feel its presence in so many ways. For example, we feel air when the trees rustle, clothes hanging on a clothes-line sway, pages of an open book flutters when the fan is switched on, when kites fly in the sky. We cannot see, touch or taste air but we can feel it. It is the air that makes all these movements possible. Thus, we can understand that air is present all around us.

Air is necessary for us to live. We can live without food for some days, without water for a few hours, but cannot survive without air for more than a few minutes. So, air is very important for all living beings to survive.

When air is moving it is called wind. It is cool and soothing as breeze. When air moves with force it can even uproot trees and blow off the roof tops. Air is necessary for breathing and also for combustion. Shall we do an activity?

Atmosphere

Our earth is surrounded by a huge envelope of air called the atmosphere. Atmosphere extends to more than 800km above the surface of earth and is held in place by the earth's gravity. The atmosphere protects us from many harmful rays coming from the sun. The air envelope is thicker near the earth's surface and as we go higher the density and the availability of air gradually decreases. This is because, as we go higher, the force of gravity decreases, so it is not able to hold large amount of air.

The atmosphere is made of five different layers – the troposphere, the stratosphere, the mesosphere, the ionosphere and the exosphere.

The troposphere is the layer closest to the earth. It is the layer in which we live. It extends upwards for about 16km above the surface of the earth. Movement of wind takes place in this layer. It also contains water vapour, which is responsible for making clouds. This layer is responsible for the weather we experience on earth.

Aircrafts usually fly above this layer to avoid strong winds and bad weather

The stratosphere lies above the troposphere. This layer has the ozone layer in it. The ozone layer protects all life on earth from the harmful ultraviolet rays of the sun.

A weathercock shows the direction in which the air is moving at a particular place. You can also make a wind sock to find the direction of the wind. Can you try it yourself?

Experimental verification of presence of Oxygen, Carbon-di-oxide and Nitrogen in Air

Is air a thing or a composite mixture?

For long time, that is, until eighteenth century, human thought 'air' as a fundamental constituent of matter. However an ingenious experiment conducted by Joseph Priestley in 1774 showed that "air is not an elementary substance, but a composition," or mixture of gases. He was also able to identify a colourless and highly reactive gas which was later named 'oxygen' by the great French chemist Antoine Lavoisier.

Priestley took a tub of water and made a float and placed a candle on it. He coveredthe candle with a glass jar. [As the bottom portion of the jar was filled with water, no air can enter or exit and hence the jar was completely sealed (Fig-1)]. As

you would have guessed the candle flame was extinguished in a very short time. He used a magnifying glass to focus the sun rays to light the candle. Thus he tried to to relight the candle many times without opening the sealed jar (Fig-2). The candle could not be relit. What can we make out of it?

It was clear that something in the air was being used for burning and being converted into another substance. Once the substance in the air that was aiding the burning was completely used by the burning flame and converted into another substance, the flame went out.

[Later chemist named the substance necessary for burning as oxygen and during the process of burning oxygen is converted mostly into carbon dioxide.]

Now as the jar was inside the water, Priestley could gently lift the jar and place a live mouse inside it without allowing outside air to enter the jar (Fig-3). Without oxygen, as you would have guessed, the mouse died (Fig-4). It was clear that oxygen was necessary for the survival of the mouse.

In the next step, he gently lifted the jar and placed a mint plant (Fig-5). (Note: Look at the Figure- 5; you could see that the plant is inserted into the bell jar when the jar is very much inside the water. This is done to ensure that the outside air is not entering into the bell jar.) Plant being a living thing like mouse, perhaps he thought, would die. Instead, the plant survived. After placing the mint plant, he lit up the candle and it continued to burn (Fig-6).
In fourth experiment, he took a jar, burned a candle and converted all oxygen into carbon dioxide. He placed a mint plantand a mouse into this jar. Both the plant and the mouse survived (Fig-7). He found that plants and animals have a synergy. Animals consume oxygen and release carbon-di-oxide and plants take up carbon dioxide and release oxygen.

During 1730 – 1799, Jan Ingenhousz showed that sunlight is essential to the plant to carry out photosynthesis and also to purify air that is fouled by breathing animals or by burning candles.

From these experiments i**t was clear that "air" was a composite mixture of many gases like oxygen and carbon-di-oxide.**

More to Know!

Daniel Rutherford, a Scottish chemist, discovered nitrogen. He removed oxygen and converted it into carbon-di-oxide using an inverted bell jar using a burning candle. He passed this air without oxygen through lime water and removed carbon-di-oxide also.

Once the carbon-di-oxide was removed in that air, neither a candle burned nor a plant breathed. Hence he was sure that the remaining air he had did not have oxygen and carbon-di-oxide. He was able to produce a gas, which showed the same property of the air without oxygen and carbon-di-oxide. Hence this gas was named 'nitrogen'.

Test for Carbon-di-oxide in air

Pour some lime water in a glass tumbler. Bubble some air using a straw through thelimewater. After a few minutes, look at the lime water carefully. The lime water will produce a white precipitate and that the lime water will eventually turn to a milky white solution. This shows the presence of carbon-di-oxide in air.

Composition of Air

From Priestley's experiment which was followed by Ingenhousz and Rutherford, we came to know that air was not just one substance. We will now describe what air is made up of. This is called composition of air.

The major component of air is nitrogen. Almost four – fifth of air is nitrogen. The second major component of air is oxygen. About one – fifth of air is oxygen. In addition to nitrogen and oxygen gases, air also contains small amount of carbon–di–oxide, water vapour and some other gases like argon, helium etc. The air may also contain some dust particles.

The composition of air in terms of percentage of its various components can be written as follows:

The composition of air changes slightly from place to place and also from season to season. For example,

- Air over industrial cities usually has a higher amount of carbon-di-oxide in it than the air over open spaces.
- Air in coastal areas may have more water vapour than inland areas.
- Air also contains more water vapour in rainy season.
- The amount of dust in the air is more in windy places than other areas.

Test for the presence of dust particles in air

You might have seen the sunlight entering into a dark room through a narrow slit and making shiny dust particles dancing merrily on the path of sunlight. Actually, the air in a room always contains some dust particles, but they are so small that normally they are not visible to us. When a beam of sunlight falls on them, the tiny dust particles become visible.

Shall we do an activity to calculate the amount of dust particles in air from our area?

Take a graph sheet. Using marker pens draw a 5x5 cm square on the graph. Apply a thin film of grease on the graph sheet. This sheet will serve as dust collector. Make four or five graph sheets.

Discuss in the whole class, as where to place the dust collectors, how long to collect dust particles and place the dust collectors in agreed positions.

Ensure that the dust collectors do not get blown away. After the time scheduled for performing this activity is reached, remove the paper and count the number of collected dust particles in the marked area in all the sheets, using a magnifying glass at the dust collector. We can see something similar to the diagram below:-

Then, calculate the mean number of dust particles in the marked area.

$$Mean = \frac{total\ number\ of\ dust\ particles\ on\ collector}{number\ of\ squares\ on\ collector}$$

The range of the dust can also be calculated as given below:-

Range = Maximum value – minimum value

Collect details from all the areas where we have kept the dust collector sheets. Tabulate the recordings in the table given below:-

Test for water vapour in air

Take a few ice cubes in a glass. Keep it on the table for a few minutes. Observe what happens. You could see tiny droplets of water all over the outer surface of the glass. From where do these droplets come? The water vapour present in the air condenses on the cold surface of the glass. This shows that air contains water vapour.

Burning and Combustion

When we burn a candle, paper, kerosene, coal, wood or cooking gas (LPG), oxygen is needed. The oxygen needed for the burning of candle, paper, kerosene, coal, wood and cooking gas comes from the air around us. Thus, for burning a substance continuously so as to make fire, a continuous supply of fresh air is needed. If we cut off the supply of fresh air to a burning substance, then the burning

substance will not get oxygen necessary for burning to continue and hence the substance will stop burning. In rockets, as they go high in the atmosphere, the availability of oxygen is considerably reduced. Therefore in rockets along with the fuel, oxygen is also carried for combustion.
The process of burning of a substance in the presence of oxygen and releasing a large amount of light and heat is called burning. If the process does not emit flame then it is called combustion.

Importance of air for survival of plants and animals

Respiration in plants

Plants require energy for their growth and hence respiration also occurs in plants. During respiration, plants take in oxygen and release carbon–di–oxide, just as animals do. Gaseous exchange with air in atmosphere takes place in plants with the help of tiny holes called stomata present on their leaves.

Photosynthesis

Plants manufacture food by a process called photosynthesis. During photosynthesis, Carbon-di-oxide from the air and water from the soil react in the presence of sunlight to produce food. Most plants possess a green pigment called chlorophyll and it is also used-up in the process of photosynthesis. The word equation given below explains the process of photosynthesis.

$$\textbf{Carbon-di-oxide + water} \xrightarrow[\textbf{Chlorophyll}]{\textbf{Sunlight}} \textbf{Food + Oxygen}$$

Plants release oxygen during photosynthesis which is much more than the oxygen consumed by the plants, during respiration.

Respiration in Animals

When we breathe in air, the oxygen present in the air reacts chemically with digested food within the body to produce carbon-di-oxide gas, water vapour and energy.

This energy is required to carry out many processes in the body such as movement, growth and repair. This process by which oxygen reacts with digested food to form carbon-di-oxide, water vapour and energy is called respiration. The process can be represented by a word equation as given
below :-

Food + Oxygen → Carbon-di-oxide + water + Energy

Carbon-di-oxide formed during respiration dissolves in the blood and is exhaled out of the body through the lungs. The inhaled and exhaled air thus contain the same substances but in different proportion, except nitrogen which is present in the same amount. Inhaled air contains more oxygen while the exhaled air contains more carbon-di-oxide.

Let us have a look at the following table to compare the composition of air in inhaled and exhaled air.

Component	**Inhaled air**	**Exhaled air**
Nitrogen	78%	78%
Oxygen	21%	16%
Carbon-di -oxide	0.03%	4%
Water vapour	Variable amount	amount increases in exhaled air
Noble gases	0.95%	0.95%
Dust	Variable amount	none
Temperature	Room temperature	Body temperature

Respiration of plants and animals in water

The water of ponds, lakes, rivers and seas have some amount of dissolved air containing oxygen in it. The plants and animals that live in water use the oxygen dissolved in water for breathing. For example, frogs respire through their skin, fish respire using their gills.

When carbon-di-oxide is cooled to -570 C, it directly becomes a solid, without changing to its liquid state. It is called dry ice and is a good r e f r i g e r a t i n g agent. Dry ice is used in trucks or freight cars for refrigerating perishable items such

as meat and fish while transporting them.

Uses of Air

- Air is used by plants and animals for breathing.
- Air is used for burning fuels like wood, coal, kerosene, LPG etc.
- Compressed air is used to fill tyres of various kinds of vehicles.
- Air plays an important role in maintaining the water cycle in the nature.
- Ozone layer, present in the atmosphere, helps in preventing harmful radiations of the sun from reaching the earth's surface.

- Under extra – ordinary conditions such as:

- Blowing air is used to turn the blades of wind mills.

The wind mills are used to draw water by running pumps, run flour mills and to generate electricity.

Unit 2 Water

Introduction

Water is one of the basic substancepresent in the earth. It plays a vital rolein the evolution and survival of life. It isimpossible to imagine life on the earthwithout water. Water helps to regulate thetemperature of our planet. It also helps tomaintain the temperature in organisms.

Where do we get water from?

We need water to perform several dayto day activities like cooking food, washingclothes, cleaning utensils etc.We get water from different watersources in our surroundings. In villages /towns wells, canals, tanks, ponds, rivers,water tanks, hand pipes are the mainsources of water.

List out the sources from where yougget water in your village/town.For example Ramu says he and his familyget water from the pipes in washroomsand kitchens. Sankar says he has to usehandpump daily both in the morning andevening to collect the water. Raja says hismother used to get up early and walks topond to get water.

Where do you get water for yourhousehold uses?

Where and how water is found on the earth?

Water is available in nature in threeforms – Solid, Liquid ,Vapour.

- Solid form of water - Ice - It is present in ice bergs and ice caps on top of tall mountains, galaciers and polar regions.
- Liquid form of water – Water – Itis present in oceans, seas, lakes, riversand even underground.
- Gaseous form of water – Vapour –It is present in the air around us.

Availability of water

We know thatnearly ¾th of the surfaceof the earth is occupied by water. Most ofthe water, that is 97% of the total amountof water that exits on earth is found in seasand oceans.

Can we drink the water available in thesea? Sea water is salty. But water used forour daily purposes is not salty. It is knownas fresh water. Water obtained from ponds, puddles, river, tube-wells and taps at homeis usually fresh water. If the total water on earth be 100%, let'ssee what percent would be the availabilityof fresh water.

From the pie chart, it can also be notedthat 97% water is saline water. Only 3%found is the freshwater and that too inpolar ice caps and glaciers. So this portionof water is not readily available for drinking.

The distribution of the totallyavailable (3%) freshwater is asfollows:

Polar ice caps and glaciers 68.7%
Ground water 30.1%
Other sources of water 0.9%
Surface water 0.3 %

The distribution of total 0.3% ofsurface water is as follows:
Lakes 87%
Rivers 2%
Swamps 11%

Thus the above pie chart explainsthat we have a very small amount of freshwater available for human usage andso maintaining the water table and theconservation of water is very essential. Isn't it?

Water while passingthrough layers of soildissolves salts andminerals to a maximum extent. These salts and minerals havebeen deposited in seas and oceansfor millions of years and are still beingdeposited. In addition, the oceanicvolcanoes which are present inside, alsoadd salts to the sea. Water with largeamounts of dissolved solids is not potableor suitable for drinking. Such water iscalled saline water.

Composition of water

Water is a transparent, tasteless,odourless and nearly colourless chemicalsubstance. It is composed of two atomsof hydrogen combined with one atom ofoxygen. The molecular formula of water is H_2O.

However, the physicalcomposition of waterchanges from place to place.

It can be clear or cloudy,oxygenated or not very oxygenated and itcan be fresh or salty. The amount of saltin water is termed as salinity. Based on itssalinity water is classified into three maincategories such as freshwater, brackishwater and sea water. Fresh water contains0.05% to 1% of salt. Brackish water containsupto 3% of salt and seawater contains morethan 3% of salt. Ocean water is composedof many substances. The salts includesodium chloride, magnesium chloride andcalcium chloride.

Water freeze at 0^{o}Celsius at normalpressure.

Every year march $22^{nd}$is observed as the world water day.

Water cycle

The water on theearth evaporates into the atmosphere due to the heat of the sun. The watervapour in the atmosphere forms clouds. From the clouds water falls on the earth in the form of rain or snow. Bythis natural process, water gets renewed.This is called **water cycle**.
Water cycle is a continuous process.

It involves three stages - **evaporation, condensation and precipitation**. It is also called the **hydrological cycle**.

Evaporation: Water from oceans,lakes,ponds and rivers evaporates due tothe heat of the sun.

Condensation: Water vapour whichenters into the atmosphere by evaporation moves upward with air, gets cooled andchanges into tiny water droplets that formclouds in the sky.

Precipitation: The millions of tinydroplets collide with one another to form larger droplets. When the air around the clouds is cool these drops of water fall inthe form of snow or rain.

Have you heard of transpiration?

It is the process of loss of water fromthe aerial parts of a plant in vapour form.

There is a continuous cycling of waterand it exists in three forms in nature.

Water evaporating from lakes, riversand oceans forms the gaseous state. Rainwater forms the liquid state. Snow onmountains and polar ice caps forms thesolid state.

These three states occur in nature, keep the total amount of water on the earth constant even when the whole world is using it!

Natural Sources of fresh water

Three types of natural sources of fresh water are available on the earth.

Surface water

Water present on the surface of theearth such as river,lake,ponds, streams orfresh water wetland is called surface water.

Frozen water

Water that is present in the frozen formas polar ice-caps and glaciers are calledfrozen water. A larger portion of water is68.7% of the total available fresh water isin frozen state.

Ground water

Ground water is the water presentbeneath Earth's surface in soil. This water isobtained through springs, open wells, tubewells, or hand pumps etc.,

The Himalayas

The Himalayas,contain ice caps, icebergs and glaciers.Ten of Asia’s largest rivers flow fromthe Himalayas and more than a billionpeople’s livelihoods depend on thoserivers.

More to know: Water, is measuredin litre and millilitre. Gallon is also ameasure of volume of liquids.

1 Gallon = 3.785 litre

Water level in the reserviors is measuredin TMC/feet. Water released from damsis measured in cusec (cubic feet/sec).

Aquatic animals

During winter, water inlakes and ponds in thecold countries will befrozen and a solid layer of ice is formedon the surface of water. Still aquaticanimals living under the ice do not die.This is because the floating layer of iceacts as a protective coat, and doesn'tpermit heat to escape from water. So asthe water at the surface alone turns toice, it the existence of aquatic animals.

Conservation of water

There is no change in the total quantity of water available on the earth. It remains the same. But the water useful for plants, animals and man is decreasing day by day. It is called scarcity of water.

What are the reasons for scarcity of water?

The main reasons for water scarcity

1. Population explosion
2. Uneven distribution of rainfall
3. Decline of ground watertable
4. Pollution of water
5. Careless use of water

We should take care to prevent scarcity of water. Otherwise,it is impossible for organisms to live on the earth. The only method of preventing scarcity of water is conservation of water. Saving water for the future generations by using water carefully and in a limited way is conservation of water.

Methods of water conservation:

Mainly, two methods can be followed for the conservation of water.

1. Water management

Water management consists of the following factors:

a. Bringing awareness about the bad effects of throwing wastes into the water bodies

b. Recycling of water by separating pollutants.

c. Minimizing the use of chemical fertilizers in agriculture. It reduces the pollution of underground water.

d. Controlling deforestation

e. Adopting drip irrigation and sprinkler irrigation in agriculture. By this way lesser amount of water can be used for the irrigation

2. Rainwater harvesting

Direct collection and use of rain water is called rainwater harvesting.
There are two types of rainwater harvesting.

a. Collecting water from where it falls.
(e.g): Collecting water from the roof tops of the houses or buildings (Roof water harvesting).

b. Collecting flowing rain water
(e.g): Collecting rainwater by constructing ponds with bund.

Coovam is an estuary!

Estuaries are wetlands where water bodies meet the sea. It is a combination of fresh water from land meeting the salty seawater. Estuaries are home to unique plants and animal species.

Importance of water

Human body: Our body uses water in all its cells, organs and tissues to help regulate its temperature and maintain other bodily functions. On an average, the human body requires 2 – 3 litres of water per day for proper functioning. Water helps in digestion of food and removal of toxins from the body.

Domestic: Apart from drinking, people use water for many other purposes. These include: cooking, bathing, washing clothes, washing utensils, keeping houses and common places clean, watering plants, etc.

Swamps are wetlands that are forested. They occur along large rivers or on the shores of large lakes. The water of a swamp may be freshwater, brackish water or seawater. Swamps are important for providing fresh water and oxygen to all life. Pichavaram Mangroves in Chidambaram, Muthupet mangrove wetland. Pallikkaranaiwetland in Chennai, Chembarambakkam in Kancheepuram are a few examples of swamps in Tamilnadu.

Agriculture: Water is also essential for the healthy growth of farm crops and farm stock and is used in the manufacture of many products.

Industry: Industry depends on water at all levels of production. It is used as a material, a solvent and for generating electricity.

2.9 Water distribution and treatment system

We know that water is distributed by local bodies. In some areas which water is obtained from river, lake and ground water is treated and distributed. Model of water distribution and treatment plant is shown in figures.

Unit 4 Our Environment

Introduction

The surroundings or space in which a person, animal, or plant lives, is known as on**environment**. Environment is everything that is surround us. It can have both living (biotic)
and non-living things (abiotic). **Abiotic** factors are non-living parts such as sunlight, air,water and minerals in soil. **Biotic** factors are living things of our environment such asplants, animals, bacteria and more. Organisms live, constantly interact with one another andadapt themselves to conditions to their environment.

The Ecosystem

Ecosystem is a community of living and non-living things that work together. Eachpart of an ecosystem has a role to play. Any changes in the environment such as increasedtemperature or heavy rains, can have a big impact on an ecosystem.
Ecosystems can be either natural or artificial.

Natural ecosystem

Ecosystem originated without humanintervention is called a **natural ecosystem.**This can be an aquatic ecosystem or aterrestrial ecosystem.

The ecosystem in water is called**aquatic ecosystem**. Sea, river, lake, pondand puddle are some examples of naturalaquatic ecosystem.

Ecosystems outside the water body andon land are called **terrestrial ecosystems.**Forests, Mountain regions, deserts etc., areexamples of natural terrestrial ecosystems.

Artificial ecosystem

Artificial ecosystems are created andmaintained by human. They have some ofthe characteristics of natural ecosystems. They are much simpler than the naturalecosystems.

These can be the terrestrial ecosystems such as paddy fields, gardens etc. or theaquatic ecosystem such as fish tank.

Aquarium:

Aquarium is a place in which fish and other water creatures and plants are maintained. An aquarium can be a small tank, or a large building with one or more large tanks.

Terrarium:

Terrarium is a place in which live terrestrial animals and plants are kept. Plants and animals are kept in a terrarium with controlled conditions that copy their natural environmentAquariums and Terrariums are used to observe animals and plants more closely. They are also used for decorations.

4.2 Food Chain and Food Web

Living organisms need food to perform their life processes. Some organisms can produce their own food, such as plants, while other organisms cannot do this and need to feed on other organisms to obtain their energy.

We can therefore identify different feeding types in an ecosystem, based on how the organism obtain (gets) its food. They are **producers and consumers**.

Producers

Producers are organisms that are able to produce their own organic food. They do not need to eat other organisms to do this. Producers are also called **autotrophs.** Can you name an organism that prepare it's own food?

Plants are producers because they make their own food by photosynthesis.

What do plants need in order to photosynthesis?

Consumers

Organisms which cannot produce their own food, need to eat other organisms as food. These organisms are called **consumers**. All animals are consumers as they cannot produce their own food. Consumers are also called **heterotrophs.**

There are many types of consumers and we can classify them into specific groups depending on the food that they consume. These are:

- **herbivores**
  Animalswhich eat plants or plant products e.g: cattle, deer, goat and rat.
- **carnivores**
  Animalsthat eat other animalse.g: Lion, tiger, frog and owl.
- **omnivores**
  Animalsthat eat both plants and animals e.g: Humans, dog and crow
- **decomposers**

Micro-organisms that obtain energy from the chemical breakdown of dead organisms (both plants and animals). They break complex organic substances into simple organic substances that goes into the soil and are used by plants. (e.g) Bacterium, Fungi

Food chain

In a forest, deer eats grass; and in turn we know tiger eats deers. In any ecosystem there is a chain like relationship between the organisms that live there. **This sequence of who eats whom in an ecosystem is called as food chain.**

It describes how organisms get energy and nutrients by eating other organisms.

A food chain shows the relationship between producers (e.g. grass) and consumers (e.g. deer, goats, cows and tiger).

Energy flow

The food chain begins with the energy given by the Sun. Sunlight triggers photosynthesis in plants. The energy from the Sun is stored in the plant parts. When the grasshopper eats the grass, the energy flows from grass to grasshopper. Frog gets energy by eating grasshopper. This energy is transferred to a crow, when the frog is eaten by a crow. Thus we conclude the primary energy production in the world of living things is made by plants; that is by photosynthesis.

The micro organism reduce the excreata and the dead bodies of animals into primary simple components and puts them back into soil. It is this material that help the plants to grow. Thus we can see that there is a cycle of materials from primary producers to highest level predators, then back to soil.

Trophic levels

We see that the energy is passed along from the producer to the consumers. But, there are three different consumers in any food chain. How can we distinguish different consumers?

Animals that eat plants are **primary consumers**.
Animals that eat primary consumers are called **secondary consumers.**

Animals that eat the secondary consumers (mostly predators) are the **tertiary consumers**.

There may even be large predators that eat tertiary consumers. They are called as **quaternary consumers**.

Each of these levels in the food chain is called a **trophic level.**

Organism uses up to 90% of its food energy for its life processes. Only about10% of energy goes into new body cells and will be available to the next animal when it gets eaten. This loss of energy at each trophic level can be shown by an **energy pyramid.**

A rat eats grains; and in turn we know snake eats rat. Now snake is a prey for peacock and in turn peacocks are easy prey for tigers and leopards. Now think? Do tigers have any natural predators?

In all food chain there is a top level predator that has no natural predators. In an aquatic ecosystem there are no natural predator for alligator; in a forest there are no natural predators for tigers.

Importance of food chain

1. Learning food chain help us to understand the feeding relationship and interaction between organisms in any ecosystem.

2. Understanding the food chain also helps us to appreciate the energy flow and nutrient circulation in an ecosystem. This is important because pollution impacts the ecosystem. The food chain can be used to understand the movement of toxic substances and their impacts.

Food web

Consumers have different sources of food in an ecosystem and do not rely on only one species for their food. If we put all the food chains within an ecosystem together, then we end up with many interconnected food chains. This is called a food web.

A food web is very useful to show the many different feeding relationships between different species within an ecosystem.

4.3 Waste Management and Recycling

To protect our environment, it is very important to reduce waste, manage it properly and maximise recycling. Waste is any substance or material that has been used but is not wanted anymore. This is either because it is worn out, broken or no longer has any purpose. Everyone produces waste and our waste has an impact on all ecosystems. However, most of us do not know where our garbage goes. There are many types of waste. There is liquid waste (in our drains), there are gases hiding in the air (like pollutants from factories), and there is solid waste (garbage) we put in our waste bins.

Biodegradable and Non- biodegradable Waste

Solid waste we generate can be classified into two major types:

1. Biodegradable waste
2. Non-biodegradable waste

Biodegradable waste

The term **'Biodegradable'** is used for those things that can be easily decomposed by natural agents like water, oxygen, ultraviolet rays of the sun, micro-organisms, etc.

One can notice that when a dead leaf or a banana peel is thrown outside,it is acted upon by several microorganismslike bacteria, fungi or smallinsects in a time period. Biodegradablewaste includes vegetable and fruit peels,leftover food and garden wastes (grass,leaves, weeds and twigs).

Natural elements like oxygen,water, moisture, and heat facilitatethe decomposition thereby breakingcomplex organic forms to simpler units.Decomposed matter eventually mixesor returns back to the soil and thus thesoil is once again nourished with variousnutrients and minerals.

Non-biodegradable waste

Those materials which cannot bebroken down or decomposed into the soilby micro-organisms and natural agentsare labeled as **non-biodegradable**.These substances consist of plasticmaterials, metal scraps, aluminum cansand bottles, etc.

These things are practically immuneto the natural processes and thus cannotbe fed upon or broken down even afterthousands of years.

Rani and her garbage

Rani gets home from school. She ishungry. She eats a banana and a packet ofchips. She puts the banana peel and plasticchips packet into the waste bin. In thewaste bin, the waste mixes together andthe banana peel makes the plastic chipspacket dirty. The waste bin starts to smelland Rani's mother puts the waste outsideon the street. The municipality collects thewaste from outside Rani's house and manyother houses ina tractor. Thetractor drives toa big open dumpand leaves allmixed wastesthere.

Sometimes, there are fires in theopen dump. When waste like Rani'schips packet burns, unhealthy chemicalspollute the ecosystem. These chemicalsare present in the air we breathe. Theleftover ash from burning waste pollutesthe soil.

When it rains, some of the dangerouschemicals goes into the ground. Someof the rain never reaches the ground asit collects in the plastic garbage at thedump. Little pools of water let mosquitoesto breed and they can spread unwanteddiseases like dengue and malaria. Cowsand dogs go into the open dump lookingfor food. As the waste is mixed, manythings that are not good to eat such asplastics, smell like food. The animalsget confused and eat some plastics byaccident. This makes them sick.

Rani is a student like you. She doesnot want to make animals sick. She doesnot want to pollute beautiful Town. Shedoes not like mosquitoes and wishes thatno one ever gets sick from them. So Ranitakes this decision "I plant trees andreduce all type of pollution".

Do you want the same as Rani does?Become a detective. Learn about the3R's and how you can start to solve theseproblems.

Solid Waste Management

It is our duty to reduce creatingwaste and protect environment. 3R's areimportant in protecting environment. Thefirst R is reduce and the second R is reuseand the last R is recycle.

The waste hierarchy or pyramid showsthe bestwaysto manage solid waste.

1. Avoid

Avoid the usage of unwanted materialswhich create more debris. Before you buyanything, think that "Do I really need it?"(e.g) Avoid buying packaged foods. Refuseto buy use and throw plastic products.

2. Reduce

We can reduce the waste by usingdurable goods that last longer instead ofthings that are used once and thrown away.

(e.g) Write on both sides of papers. Insteadof unnecessary printing, use electronicfacilities. Share newspapers, magazines
and other things with others.

3. Reuse

Reusing means using a thing again andagain, rather than using and throwing aftera single use. (e.g) Instead of using plasticbags, use and throw pens and batteries, usecloth bags, fountain pens and rechargeablebatteries. Reuse glass bottles for otherpurposes. Repair foot wears and use them.

Creative reuse

Creative reuse or Up-cycling is the processof converting wastematerials or useless products into newmaterials or products of better qualityor for better environmental value. Whenyou upcycle, you are giving an item anew purpose. (e.g) Used tyres intochairs.Used PET bottle into penstand.

4. Recycle

The process by which waste materialsare used to make new products is calledrecycling.(e.g) Using old clothes to make
paper and melting some plastics to makefloor mats, plastic boards and hose pipes.

5. Compost

The process of degradation of organicwastes into manure by the action ofmicroorganism is called **composting.** Themanure thus obtained becomes naturalfertilizer for the plants as well as increasesthe soil fertility.

6. Incinerate

The burning of solid waste in incinerator is called incineration. Human anatomical wastes (discarded medicines, toxic drugs, blood, pus) are disposed by means of incineration. During incineration, the enormous heat kills all contagious disease-causing germs. We can also produce electricity with the help of this heat.

7. Landfill

Landfilling is a method in which wastes are dumped into naturally occurring or man-made pits and covered with soil. Garbage buried inside landfills remain here for a long time as they decompose very slowly and become manure. These places can be converted into parks, gardens, etc.,

Earlier in the chapter, you learn about Rani and how she did not want to causepollution. Simple steps in your daily life can make big differences. There are two steps you should remember.

1. The first step should always be to reduce waste. Think of the 3R's and the waste pyramid and remember the order of the levels.
2. The second step is to keep waste separate. This way the waste will remain clean and can be easily reused or recycled. Mixing different types of waste together (e.g. biodegradable and non-biodegradable) makes waste dirty. Dirty waste gets sent to a landfill or open dump.

Waste separation exercise

The Solid Waste Management (SWM) rules, 2016 say that,

1. Every Household should segregate and store the waste generated by them in **three separate streams – namely bio-degradable, non bio-degradable and domestic hazardous waste** in suitable bins and handover segregated wastes to authorised waste pickers or waste collector as per the direction or notification by the local authorities from time to time.

2. No body shall throw, burn, or bury the solid waste on streets, open public spaces outside his premises or in the drain or water bodies.

Domestic hazardous waste means discarded paint drums, pesticide cans, CFL bulbs, tube lights, expired medicines,broken mercury thermometers, used batteries, used needles and syringes and contaminated gauge, etc., generated at the household level.

Learn how to separate waste correctly into 3 waste bins so you can keep Tamilnadu clean and beautiful!

How much waste does each person make around the world every day?

The average person in India produces 0.45kg of waste every day. It may be small amount of waste. But, India has a large population and imagine you collected all the waste today and put it into tractors. You would fill so many tractors that you could create a traffic jam approximately 2,800 kilometres long. Imagine, a road all the way from Kanyakumari to New Delhi completely blocked with tractors carrying garbage and no space to walk in between. This is how much waste we create in India each day! If we reduce the waste, we reduce the pollution.

India produces 532 million kilos of solid waste every day.

Pollution

Pollution occurs when the environment gets contaminated by waste, chemicals and harmful substances.

Pollution is the damage caused to the environment mainly because of human activities. Any substance that causes pollution is known as a **pollutant**. Pollution is

an unwanted change in the physical, chemical and biological characteristics of our land, air and water.

4.6 Types of Pollution

There are four major kinds of pollution:

1.Airpollution
2.Water pollution
3.Land (soil) pollution
4. Noise pollution

4.6.1 Air pollution

Most air pollution is caused by the burning of fossil fuels (e.g. oil, petrol, coal and natural gas). These fossil fuels are used in factories (industries), power plants and motor vehicles. Burning these fossilfuels release toxic gases and fine particles (such as ash and soot) into the air causing air pollution. Air pollution is also caused by burning solid waste (especially some plastics), gases or chemicals released from factories and fumes from aerosols (like deodorant spray cans) or paints.

Certain toxic gases produced by industries mix with raindrops high in the atmosphere and make rain unusually acidic. This is called acid rain. It damages plants, washes the nutrients out of soils and kills fish. Air pollution is harmful to all living organisms including humans. Polluted air affects skin, eyes and respiratory system.

How can we reduce air pollution?

1. Cycle or walk short distances instead of using a motor vehicle.
2. Travel by public transport (bus or train)
3. Do not burn solid waste.
4. Avoid fireworks.

4.6.2 Water pollution

Water pollution occurs when wastes from factories, houses and farms mixes with the water in rivers, lakes, ponds, the ocean or even groundwater. Contaminated or polluted water can spread diseases and chemicals which are not good for our health.

The most significant sources of water pollutants are

1. Sewage (water we use at home forbathing, cleaning, cooking).
2. Industrial effluents (liquid wastes from factories).
3. Agricultural pollutants (chemicalpesticides and fertilisers that getwashed from farms).
4. Solid waste (when waste gets dumpedinto water bodies).

How can we reduce water pollution?

1. Do not pour leftover oil, old medicinesor waste down the drain or into thetoilet.
2. Reduce the use of chemical pesticidesand fertilizers to grow crops.
3. Use waste water for garden in home.
4. Do not litter or dump waste – alwaysuse a waste bin.

4.6.3 Land (soil) pollution

In the same way as water and air getpolluted, land or soil pollution happenswhen toxic chemicals change the naturalbalance in soil. Land pollution comes fromfarming (Excess use of chemical pesticidesand fertilisers), mining (digging up metalsand other materials), factories (industrialwaste) and the solid waste from our ownhomes like plastics and broken electronics.Soil pollution affects animals, humans andeven plants because soil or land acts like asponge. When it rains, pollutant sinkss intothe soil. If we grow plants to eat in pollutedsoils, these dangerous chemicals can getinto our food.

How can we reduce land pollution?

1. First try to reduce waste, then recyclethe rest.
2. Always use a waste bin and never litter.
3. Do not burn waste, the ash mixeseasily with soil.

4.6.4 Noise pollution

Noise pollution affects the environment.We all like a quiet and peaceful place sinceunpleasant or loud sounds disturb us. Loudmusic, the sounds of motor vehicles, fireworks and machines cause noise pollution.Continuous noise disturbs our sleep anddoes not let us to study. Noise pollution hasbeen directly linked to stress and healthimpacts such as high blood pressure andhearing loss. Loud noise or even loud musiccan damage our ears. Noise pollution alsodisturb animals. Birds have to communicate(talk) louder so that, they can hear eachother in noisy areas. Even underwater noisepollution from ships, can make whales losetheir way as they use sounds to navigate.

How do we reduce noise pollution?

1. Turn off your electronics when you donot use them.
2. Lower the volume when you watch TVor listen to music.
3. Remind drivers not to use the horn toomuch.
4. Avoid fireworks.
5. Speak, do not shout (try to set anexample).

8th term 2 - Unit 3
Air

Introduction

Air is a mixture of gases that surrounds our planet earth. It is essential for the survival of all the living things. Air contains 78.09% nitrogen, 20.95% oxygen, 0.93% argon, 0.04% carbon dioxide and small amount of other gases. We breath in oxygen and breath out carbon dioxide. Plants in turn use carbondioxde for photosynthesis and release oxygen into the atmosphere. Since men have been cutting down trees for their needs, the amount of carbon dioxide in the atmosphere is increasing. This is responsible for the raising of atmospheric temperature. Industries and vehicles release gases like carbon monoxide and sulpher dioxide into the atmosphere. This has resulted in effects like global warming and acid rain which affect us in many ways. In total, the quality of air is gone in the modern days. In this lesson we are going to study about the effects like green house effect, global warming and acid rain. We will also study about occurrence and properties of the gases oxygen, nitrogen and carbon dioxide.

3.1 Oxygen

All living things in the world need oxygen. We cannot imagine the world without oxygen. Swedish chemist C.W. Scheele first discovered oxygen in 1772. He called the gas fire air or vital life because it was found to support the process of burning. It was independently discovered by the British scientist Joseph Priestley in 1774. Lavoisier named oxygen. The name oxygen comes from the Greek word 'oxygenes' which means 'acid producer'. It is called so because early chemists thought that oxygen is necessary for all acids.

3.1.1 Occurrence of Oxygen

Oxygen is the most abundant element on the earth by mass and the third most abundant element after Hydrogen and Helium in the universe. It occurs both in free state and combined state. It is present in free state as dioxygen molecule (O_2) in the atmosphere. Most of this has been produced by the process photosynthesis in which the chlorophyll present in the leaves of plants uses solar energy to produce glucose.

Oxygen in free state		**Oxygen in combined state**	
Source	Percentage	Source	Percentage
Atmospheric air	21 %	Plants and animals	60 – 70 %
Water	88 – 90 %	Minerals in the form of silicates, carbonates and oxides	45 – 50 %

6CO2 + 6H2O + Energy from the Sun C6H12O6 + 6O2.

In combined state it is present in the earth's crust as silicates and metal oxides. It is also found in the water on the surface of the earth. Tri oxygen molecule (O3) known as ozone is present in the upper layers of the atmosphere.

3.1.2 Physical properties of Oxygen

.Oxygen is a colourless, odourless and tasteless gas.
.It is a poor conductor of heat and electricity
.Oxygen dissolves readily in cold water.

Oxygen is about two times more soluble in water than nitrogen. If it had the same solubility asnitrogen, then less oxygen would be present in seas, lakes and rivers that will make life much more difficult for living organisms.

.It is denser than air.
.It can be made into liquid (liquified) at high pressure and low temperature.
.It supports combustion.

Chemical properties of Oxygen

1. Combustibility

Oxygen is a non-combustible gas as it does not burn on its own. It supports the combustion of other substances.

If oxygen has the capacity to burn itself, striking a match stick will be enough to burn all the oxygen in our planet's atmosphere.

2. Reaction with metals

Oxygen reacts with metals like sodium, potassium, magnesium, aluminium, iron etc., to form their corresponding metal oxides which are generally basic in nature. But the metals differ in their reactivity towards oxygen.

Metal + Oxygen Metal oxide

Example

4Na + O2 2Na2O

Sodium Oxygen Sodium oxide.

Activity 1
Heat a strip of magnesium ribbon in the flame till it catches fire and introduce it into

the jar containing oxygen. It burns with a dazzling bright light and white ash of magnesium oxide is formed.

Table 3.2 Reactivity of Oxygen with metals

Metal	**Condition**	**Product formed**
K	Room temperature	Potassium Oxide (K2O)
Mg Heating	Heatingslightly	Magnesium Oxide(MgO)
Ca	Heating slightly	Calcium Oxide (CaO)
Fe Cu Ag	High temperature	Iron Oxide (Fe3O4) Cupric Oxide (CuO) Silver Oxide (Ag2O)
Au Pt	Even at high temperature	No action

3. Reaction with non metals

Oxygen reacts with various non-metals like hydrogen, nitrogen, carbon, sulphur, phosphorus etc., to give corresponding non metallic oxides which are generally acidic in nature.

Non-metal + Oxygen Non-metallic oxide

Example
C + O2 CO2
Carbon Oxygen Carbon dioxide

Table 3.3 Reactivity of Oxygen with non metals

Non metal	**Products formed**
C	Carbon dioxide (CO2)
N	Nitric oxide (NO)
S	Sulphur dioxide (SO2)
P	Phosphorus trioxide (P2O3) or Phosphorus pentoxide (P2O5)

Activity 2
Heat a small piece of phosphorous and introduce it into the oxygen jar. Phosphorous burns withsuffocating smell and gives phosphorous pentaoxide (white fumes).

4. Reaction with Hydrocarbons

Hydrocarbons (compound containing C and H) react with oxygen to form carbon dioxide and water vapour. E.g. Wood, Petrol, Diesel, LPG, etc. When they burn in oxygen, they produce heat and light energy. Hence they serve as fuel.

Hydrocarbon + O2 CO2 + Water + Heat + Light
vapour energy

5. Rusting

The process of conversion of iron into its hydrated form of oxide in the presence of air and moisture (humid atmosphere) is called rusting. Rust is hydrated ferric oxide.

4Fe + 3O2 2Fe2O3 Fe2O3+ X H2O Fe2O3• X H2O
(rust)

(X = Number of water molecules which isvariable)

Uses of Oxygen

.It is used as oxy-acetylene light for cutting and welding metals.
.It is used to remove carbon impurities from steel.
.Plants and animals use oxygen from the air for respiration.
.It is used to oxidize rocket fuel.
.It is used for artificial respiration by scuba divers, mountaineers, astronauts, patients etc.
.Mixed with powdered charcoal it is used as explosives.
.It is used in the synthesis of methanol and ammonia.

Nitrogen

Nitrogen is one of the most important elements. Animals and plants need nitrogen for their growth. All living organisms (including us) contain nitrogen. It is an essential element present in proteins and nucleic acids which are the 'building blocks' of all living things. It was first isolated from the air by Swedish chemist Carl Wilhelm Scheele in 1772. The name 'nitrogen' is derived from the Greek words 'nitron' and 'gene' meaning 'I produce nitre'. Nitre is potassium nitrate compound of nitrogen. Antoine Lavoisier suggested the name azote, from the Greek word meaning 'no life

Occurrence of Nitrogen

Nitrogen is the fourth most abundant element in the human body by mass. It accounts for about three percent of the mass of the human body. It is thought to be the seventh most abundant element in the universe by mass. Titan, the largest moon of Saturn, has an atmosphere made up of 98% Nitrogen. Nitrogen occurs both in free state and combined state. Nitrogen exists in freestate in the atmospheric air as

dinitrogen (N2).It is present in volcanic gases and gases evolved by burning of coal. Nitrogen is present in combined state in the form of minerals like nitre (KNO3) and chile salt petre (NaNO3). It is present in organic matters such as protein ,enzymes, nucleic acid etc.

3.2.2 Physical properties of Nitrogen

.It is a colourless, tasteless and odourless gas.
.It is slightly lighter than air.
.It is slightly soluble in water.
.Nitrogen becomes a liquid at low temperature and looks like water.
.When it freezes, it becomes a white solid.
.It is neutral to litmus like oxygen.

3.2.3 Chemical properties of Nitrogen

1. Chemical reactivity

Nitrogen is inactive at ordinary conditions. It combines with many elements at high temperature and pressure or in the presence of catalyst.

2. Combustibility

Nitrogen is neither combustible nor a supporter of combustion. So nitrogen in the air moderates the rate of combustion.

3. Reaction with metals

Nitrogen reacts with metals like lithium, calcium, magnesium etc., at high temperature to form their corresponding metal nitrides.

Metal + Nitrogen Metal nitride

Example
3Ca + N2 Ca3N2
Calcium Nitrogen Calcium nitride.

4. Reaction with non metals

Nitrogen reacts with non-metals like hydrogen, oxygen etc., at high temperature to form their corresponding nitrogen compounds.

Non-metal + Nitrogen Nitrogen compound

Example
3H2 + N2 2NH3
Hydrogen Nitrogen Ammonia

Uses of Nitrogen

.Liquid nitrogen is used as a refrigerant.
.It provides an inert atmosphere for conducting certain chemical reactions.
.It is used to prepare ammonia (by Haber's process) which is then converted into fertilizers and nitric acid.
.It is used for inflating tyres of vehicles.
.It is used for filling the space above mercury in high temperature thermometer to reduce the evaporation of mercury.
.Many explosives such as TNT (Trinitrotoluene), nitroglycerin, and gun powder contain nitrogen.
.It is used for the preservation of fresh foods, manufacturing of stainless steel, reducing fire hazards, and as part of the gas in incandescent light bulbs.

Now a days nitrogen is used as a substitute for compressed air in tyres. Have you noticedit? Why do people prefer nitrogen instead of compressed air in tyres?

Nitrogen fixation

Nitrogen gets circulated in the air, soil and living things as the element itself or in the form of its compounds. Just as there is a circulation of carbon in nature so also there is a circulation of nitrogen. It is essential for the proper growth of all plants. The plants cannot make use of the elemental nitrogen from the air as such. The plants require soluble compounds of nitrogen. Thus, plants depend on other processes to supply them with nitrates. Any process that converts nitrogen in the air into a useful nitrogen compound is called nitrogen fixation. Fixation of nitrogen is carried out both naturally and by man.

Carbon dioxide

Carbon dioxide is a chemical compound in which one carbon and two oxygen atomsare bonded together. It is a gas at room temperature. It is represented by the formula CO_2. It is found in the earth's atmosphere and it sends back the solar energy which is reflected by the surface of the earth, to make it possible for living organisms to survive. When carbon dioxide accumulates more in the atmosphere itproduces harmful effects.

Occurrence of Carbon dioxide

Carbon dioxide is present in air to the extent of about 0.03% in volume. It is evolved by the plants and animals during respiration and is produced during fermentation reactions. Much of the naturally occurring CO_2 is emitted from the magma through volcanoes. CO_2 may also originate from the bio degradation of oil and gases. Human CO_2 emissions upset the natural balance of the carbon cycle. Man-made CO_2 in the atmosphere has increased global temperatures which is

warming the planet. While CO2 derived from fossil-fuel is a very small component of the global carbon cycle, the extra CO2 is cumulative because the natural carbon exchange cannot absorb all the additional CO2.

Physical properties of Carbon dioxide

.Carbon dioxide is a colourless and odourless gas.
.It is heavier than air.
.It does not support combustion.
.It is fairly soluble in water and turns blue litmus slightly red. So it is acidic in nature.
.It can easily be liquified under high pressure and can also be solidified. This solid form of CO2 is called dry ice which undergoes sublimation.

The process of conversion of solid into vapour without reaching liquid state is called sublimation.

Chemical properties of Carbon dioxide

1. Combustibility

It is non-combustible and not a supporter of combustion.

2. Reaction with metals

Lighter metals like sodium, potassium and calcium, combine with CO2 to form corresponding carbonates whereas magnesium gives its oxide and carbon.

Example
4Na + 3CO2 2Na2CO3 + C
Sodium Sodium carbonate
2Mg + CO2 2MgO + C
Magnesium Magnesium oxide

3. Reaction with sodium hydroxide (Alkali)

Sodium hydroxide (base) is neutralized by carbon dioxide (acidic) to form sodium carbonate (salt) and water.

Base + Acid Salt + Water
2NaOH + CO2 Na2CO3 + H2O
Sodium carbonate.

4. Reaction with Lime water

(Calcium hydroxide)

When a limited amount of CO2 is passed through lime water, it turns milky due to the formation of insoluble calcium carbonate.

$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$
Calcium carbonate

When an excess amount of CO2 is passed through lime water, it first turns milky and the milkyness disappears due to the formation of soluble calcium hydrogen carbonate, $Ca(HCO_3)_2$.

Venus' atmosphere consists of roughly 96-97% carbon dioxide. Because of the amount of carbon dioxide present, the surface of Venus continually retains heat and as such, the surface temperature of Venus is roughly 462°C, making it the hottest planet in our solar system.

Uses of Carbon dioxide

.CO2 is used to prepare soft drinks or aerated drinks.
.It is used in fire extinguishers
.It is used in manufacturing sodium carbonate by Solvay process.
.Solid carbon dioxide, called as dry ice is used as a refrigerant. The gas is so cold that moisture in the air condenses on it, creating a dense fog which is used in stage shows and movie effects.
.It is used along with ammonia in the manufacture of fertilizers like urea.
.CO2 can be used in the preservation of food grains, fruits etc.

Aerated water is nothing but carbon dioxide dissolved in water under pressure. This is also called 'soda water'.

Green House Effect and Global Warming

The solar radiation is absorbed by the surface of land and ocean. In turn, they release infra red radiation
or heat into the atmosphere. Certain gaseous molecules present in the atmosphere absorb the infra redrays and reradiate the heat in all directions. Hence, these gases maintain the temperature of earth's surface. The gases which absorb these radiations are called green house gases and this effect is called green house effect.

The green house gases are CO2, N2O, CH4, CFC (Chlorofluoro carbon) etc. The increase in the levels of these gases results in the gradual increase of temperature of the earth's surface.This increased green house effect is caused due to increase in the air pollutants and it results in the average increase of temperature of the atmosphere. This is called as Global warming.

Effects of Global warming

The following are the effects of global warming.

.Melting of ice cap and glaciers.
.Increase in frequency of floods, soil erosion and unseasonal rains.
.Loss of biodiversity due to the extinction of coral reefs and other key species.
.Spreading of waterborne and insectbornediseases.

Preventive measures

In order to save the earth and its resources we need to take certain measures. Some of the measures are given below.

.Reduction in the use of fossil fuels.
.Controlling deforestation.
.Restricting the use of CFCs.
.Planting more trees.
.Reducing, reusing and recycling resources.

Acid rain

Rain water is actually the purest form of water. However, pollutants such as oxides of nitrogen and sulphur in the air released by factories, burning fossil fuels, eruption of volcanoes etc., dissolve in rain water and form nitric acid and sulphuric acid which adds up to the acidity of rain water. Hence, it results in acid rain.

Acid rain has pH less than 5.6 whereas pH of pure rain water is around 5.6 due to dissolution of atmospheric CO_2 in it.

Effects of Acid rain

Acid rain affects us in many ways. Some of the consequences are given below.

.It irritates eyes and skin of human beings.
.It inhibits germination and growth of seedlings.
.It changes the fertility of the soil, destroys plants and aquatic life.
.It causes corrosion of many buildings, bridges, etc.

Preventive measures

Acid rain and its effects can be controlled by the following ways.

.Minimizing the usage of fossil fuel such as petrol, diesel etc.,
.Using CNG (Compressed Natural Gas).
.Using non-conventional source of energy.
.Proper disposal of the industrial wastes.

Unit- 24 – Environmental Science

Introduction

"Nature has the power to refresh and renew" - Helen Keller
Elements of nature continuously undergo changes and transformations. Environmental protection provides holistic knowledge about natural processes, effects of human intervention and solutions to overcome environmental problems. Environmental issues such as pollution, global warming, ozone layer depletion, acid rain, deforestation, landslide, drought and desertification have gained major focus across the world. Natural resources are recycled over and over again on earth for continued availabilty. At the same time, it also reminds us of our responsibility to reduce and restrain our activities that will affect the natural processes.

Living organisms adjust themselves according to their habitat and changes in the ecosystem. All living organisms develop certain morphological, anatomical, physiological and reproductive adaptations which help them to survive better and to withstand environmental conditions.

This lesson deals with bio-geo-chemical cycles, adaptations by the plants and animals, water conservation and recycling of water.

Biogeochemical Cycles (bio – life; geo – earth)

Biosphere is the part of the earth where life exists. All resources of biosphere can be grouped into two major categories namely:
(i) Biotic or living factors which include plants, animals and all other living organisms.
(ii) Abiotic or non-living factors which include all factors like temperature, pressure, water, soil, air and sunlight which affect the ability of organisms to survive and reproduce.

There is a constant interaction between biotic and abiotic components in the biosphere and that makes the biosphere a dynamic and stable system. Cyclic flow of nutrients between non-living and living factors of the environment are termed as bio-geo-chemical cycles. Some of the important biogeochemical cycles are:

1.Water cycle 2. Nitrogen cycle 3. Carbon cycle

Water Cycle

Water cycle or hydrological cycle is the continuous movement of water on earth. In this process, water moves from one reservoir to another by processes such as evaporation, sublimation, transpiration, condensation, precipitation, surface

runoff and infiltration, during which water converts itself to various forms like liquid, solid and vapour (Fig. 24.1).

Evaporation: Evaporation is a type of vaporization, where liquid is converted to gas before reaching its boiling point. Water evaporates from the surface of the earth and water bodies such as the oceans, seas, lakes, ponds and rivers.

Sublimation: Sublimation is conversion of solid to gas, without passing through the intermediate liquid phase. Ice sheets and ice caps from north and south poles, and icecaps on mountains, get converted into water vapour directly, without converting into liquid.

Transpiration: Transpiration is the process by which plants release water vapour into the atmosphere through stomata in leaves and stems.

Condensation: Condensation is the changing of gas phase into liquid phase and is the reverse ofvaporisation. At higher altitudes, the temperature is low. The water vapour present there condenses to form very tiny particles of water droplets. These particles come close together to form clouds and fog.

Precipitation: Due to change in wind or temperature, clouds combine to make bigger droplets, and pour down as precipitation(rain). Precipitation includes drizzle, rain, snow and hail.

Run off : As the water pours down, it runs over the surface of earth. Runoff water combines to form channels, rivers, lakes and ends up into seas and oceans.

Infiltration: Some of the precipitated water moves deep into the soil. Then it moves down and increases the ground water level.

Percolation: Some of the precipitated water flows through soil and porous or fractured rock.
Infiltration and percolation are two related but different processes describing the movement of water through soil.

Human impacts on water cycle

Major human activities affecting the water cycle on land are urbanisation, dumping of plastic waste on land and into water, polluting water bodies and deforestation.

Nitrogen Cycle

Nitrogen is the important nutrient needed for the survival of all living organisms. It is an essential component of proteins, DNA and chlorophyll. Atmosphere is a rich source of nitrogen and contains about 78% nitrogen. Plants and

animals cannot utilize atmospheric nitrogen. They can use it only if it is in the form of ammonia, amino acids or nitrates.

Processes involved in nitrogen cycle are explained below.

Nitrogen fixation : Nitrogen fixation is the conversion of atmospheric nitrogen, which is in inert form, to reactive compounds available to living organisms. This conversion is done by a number of bacteria and **blue green algae** (Cyanobacteria).

Leguminous plants like pea and beans have a symbiotic relationship with nitrogen fixing bacteria *Rhizobium*. Rhizobium occur in the root nodules of leguminous plants and fixes nitrogenous compounds.

Nitrogen assimilation: Plants absorb nitrate ions and use them for making organic matter like proteins and nucleic acids. Herbivorous animals convert plant proteins into animal proteins. Carnivorous animals synthesize proteins from their food.

Ammonification: The process of decomposition of nitrogenous waste by putrefying bacteria and fungi into ammonium compounds is called ammonification. Animal proteins are excreted in the form of urea, uric acid or ammonia. The putrefying bacteria and fungi decompose these animal proteins, dead animals and plants into ammonium compounds.

Nitrification:The ammonium compounds formed by ammonification process are oxidised to soluble nitrates. This process of nitrate formation is known as nitrification. The bacteria responsible for nitrification are called as nitrifying bacteria.

Microorganisms involved in nitrogen cycle

Role played in nitrogen cycle	**Name of the Microorganisms**
Nitrogen fixation	Azotobacter (in soil) Rhizobium (in root nodules) Blue green algae- Nostoc
Ammonification	Putrefying bacteria, Fungi
Nitrification	Nitrifying bacteria i. Nitrosomonas ii. Nitrobacter
Denitrification	Denitrifying bacteria Pseudomonas

animals release carbon into atmosphere in the form of carbon dioxide. Carbon dioxide is also returned to the atmosphere through decomposition of dead organic matter, burning fossil fuels and volcanic activities.

Human impacts on carbon cycle

More carbon moves into the atmosphere due to burning of fossil fuels and deforestation. Most of the carbon in atmosphere is in the form of carbon dioxide. Carbon dioxide is a greenhouse gas. By increasing the amount of carbon dioxide, earth becomes warmer. This leads to greenhouse effect and global warming.

Adaptations of Plants

Any feature of an organism or its part that enables it to exist under conditions of its habitat is called adaptation. On the basis of water availability, plants have been classified as:

(i) Hydrophytes
(ii) Xerophytes
(iii) Mesophytes

Hydrophytes

Plants growing in or near water are called hydrophytes. Hydrophytes may be free floating or submerged plants living in lakes, ponds, shallow water, marshy lands and marine habitat. Hydrophytes face certain challenges in their habitat. They are:

(i) Availability of more water than needed.
(ii) Water current may damage the plant body.
(iii)Water levels may change regularly.
(iv) Maintain buoyancy in water.

Adaptations of hydrophytes

1. Roots are poorly developed as in *Hydrilla*or absent as in *Wolffia*.
2. Plant body is greatly reduced as in *Lemna*.
3. Submerged leaves are narrow or finely divided. e.g. *Hydrilla*.
4. Floating leaves have long leaf stalks to enable the leaves move up and down in response to changes in water level. e.g. Lotus.
5. Air chambers provide buoyancy and mechanical support to plants as in *Eichhornia*(swollen and spongy petiole).

Xerophytes

Plants that grow in dry habitat are called xerophytes. These plants develop special structural and physiological characteristics to meet the following conditions:

(i) To absorb as much water as they can get from the surroundings.
(ii) To retain water in their organs for very long time.
(iii) To reduce the transpiration rate.
(iv) To reduce consumption of water.

Adaptations of xerophytes

1. They have well developed roots. Roots grow very deep and reach the layers where water is available as in *Calotropis*.
2. They store water in succulent water storing parenchymatous tissues. e.g. *Opuntia*, *Aloe vera*.
3. They have small sized leaves with waxy coating. e.g. *Acacia*. In some plants, leaves are modified into spines. e.g. *Opuntia*.
4. Some of the xerophytes complete their life cycle within a very short period when sufficient moisture is available

Mesophytes

Mesophytes are common land plants which grow in situations that are neither too wet nor too dry. They do not need any extreme adaptations.

Adaptations of mesophytes

1. The roots of mesophytes are well developed and are provided with root caps.
2. The stem is generally straight and branched.
3.The leaves are generally broad and thin.
4. The presence of waxy cuticle in leaves traps the moisture and lessens water loss.
5. Leaves have stomata which close in extreme heat and wind to prevent transpiration.

Adaptations of Animals

Animals can adapt themselves according to their habitat. Temperature and light are forms of energy which influence various stages of life activities such as growth, metabolism, reproduction, movement, distribution and behaviour. Animals develop special features or behaviour patterns to escape from extreme conditions of temperature and light. In this context, let us study about the adaptive features of bat and earthworm.

Adaptations of Bat

Bats are the only mammals that can fly. Mostly, bats live in caves. Apart from caves, bats also live in trees, hollowed logs and rock
crevices. They are extremely important to humans as they reduce insect population and help to pollinate plants. Adaptations of bat in relation to their habitat are explained below.

Nocturnality

Bats are active at night. This is a useful adaptation for them, as flight requires a lot of energy during day. Their thin, black wing membrane (Patagium) may cause excessive heat absorption during the day. This may lead to dehydration.

Flight adaptation

Forelimbs are modified serve wings. Tail supports and controls movements during flight. Muscles are well developed and highly powerful and achieve in beating of wings. Tendons of hind limbs provide a tight grasp when the animals are suspended upside down at rest.

Hibernation

Hibernation is a state of inactivity in which the body temperature drops with a lowered metabolic rate during winter. Bats are warm blooded animals but unlike other mammals, they let their internal temperature reduce when they are resting. They go to a state of decreased activity to conserve energy.

Echolocation

Bats use a remarkable high-frequency system called echolocation. Bats give out high-frequency sounds (**ultrasonic sounds**). These sounds are reflected back from its prey and perceived by the ear. Bats use these echoes to locate and identify the prey.

Adaptations of Earthworm

It is commonly found in soil, feeding on live and dead organic matter. Earthworm plays a vital role in maintaining soil fertility. It facilitates aeration, water infiltration and producing organic matter to increase crop growth. Some of the adaptations of earthworm are:

Stream-lined body

The earthworm has a cylindrical, elongated and segmented body. This helps them to live in narrow burrows underground and for easy penetration into the soil.

Skin

Mucus covers the skin which does not allow soil particles to stick to it. Moist skin helps in oxygenation of blood.

Burrowing

Its body is flexible having circular and longitudinal muscles which help in movement and subsoil burrowing. Each segment on the lower surface of the body has number of **setae**. They help the earthworm to move through the soil and provide anchor in the burrows.

Aestivation

When the soil becomes too hot or dry, earthworms become inactive and undergo a process called aestivation. Earthworm moves deeper into the soil. It secretes mucus and lowers their metabolic rate in order to reduce water loss. They remain dormant until conditions become favourable. They come out of their burrow during rainy season.

Nocturnality

Earthworms are sensitive to light. It has no eyes but can sense light through light sensitive cells (**Photoreceptors**) present in their skin. They react negatively to bright light

Earthworms are referred as '***Farmer's friend'.*** After digesting organic matter, earthworms excrete a nutrient-rich waste product called castings which is used as Vermicompost.

(Photophobic). It remains in its burrow during the day to avoid light.

Water Conservation

Water conservation is the preservation, control and management of water resources. It also includes activities to protect the hydrosphere and to meet the current and future human demand.

Importance of Water Conservation

- It creates more efficient use of the water resources.
- It ensures that we have enough usable water.
- It helps in decreasing water pollution.
- It helps in increasing energy saving.

Water Conservation Measures
Industrial conservation

Water conservation measures that can be taken by industries are:

- using dry cooling systems.
- if water is used as cooling agent, reusing the water for irrigation or other purposes.

Agricultural conservation

Agricultural water is often lost due to leaks in canals, run off and evaporation. Some of the water conserving methods are:

- using lined or covered canals that reduce loss of water and evaporation.

- using improved techniques such as sprinklers and drip irrigation.
- encouraging the development of crops that require less water and are drought resistant.
- mulching of soil in vegetable cultivation and in horticulture.

World Water Day on 22nd March every year, is about focusing attention on the importance of water.

Domestic conservation

All of us have the responsibility to conserve water. We can conserve water by the following activities:

- Using a bucket of water to take bath than taking a shower.
- Using low flow taps.
- Using recycled water for lawns.
- Repairing the leaks in the taps.
- Recycling or reusing water wherever it is possible.

Strategies adopted to conserve Water

(i) Rain water harvesting.
(ii) Improved irrigation techniques.
(iii) Active use of traditional water harvesting structures.
(iv) Minimising domestic water consumption.
(v) Awareness on water conservation.
(vi) Construction of farm ponds.
(vii) Recycling of water.

Farm Ponds

Farm ponds are used as one of the strategies to support water conservation. Much of the rainfall runs off the ground. The run off not only causes loss of water but also washes away precious top soil. Farm ponds help the farmers to store water and to use it for irrigation.

Layout of a Farm Pond

Farm pond is a dugout structure with definite shape and size. They have proper inlet and outlet structures for collecting the surface runoff flowing from the farm area. The stored water is used for irrigation.

Advantages of Farm Ponds

The advantages of farm ponds are:

- They provide water to growing crops, without waiting for rainfall.

- They provide water for irrigation, even when there is no rain.
- They reduce soil erosion.
- They recharge ground water.
- They improve drainage.
- The excavated soil can be used to enrich soil in fields and levelling lands.
- They promote fish rearing.
- They provide water for domestic purposes and livestock.

Water Recycling

Water recycling, apart from rain water harvesting, is also one of the key strategies to conserve water. Water recycling is reusing treated wastewater for beneficial purposes such as agricultural and landscape irrigation, industrial processes, flushing in toilets and ground water recharge.

Wastewater Recycling Stages

Conventional waste water treatment consists of a combination of physical, chemical and biological processes which remove solids, organic matter and nutrients from waste water. The waste water treatment involves the following stages:

Primary treatment

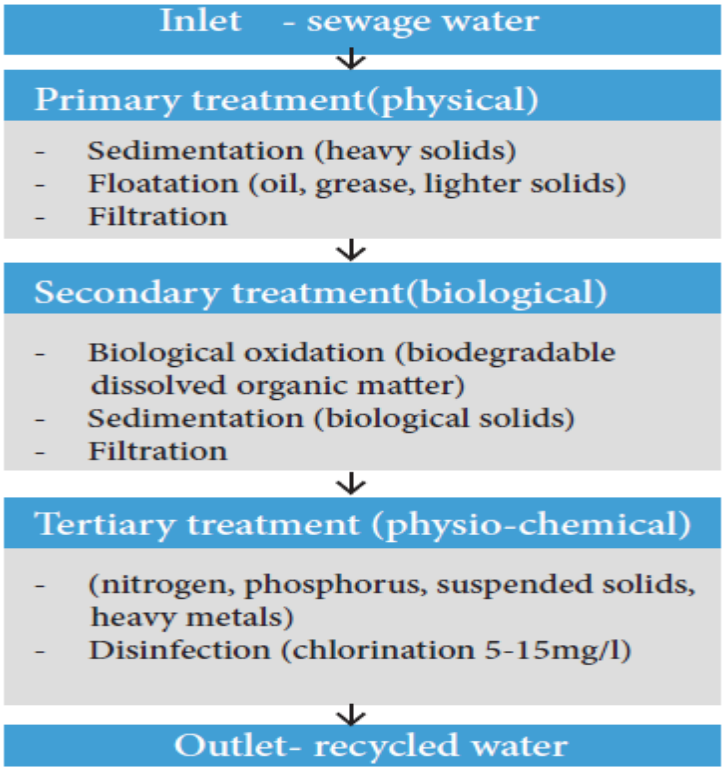
Primary treatment involves temporary holding of the wastewater in a tank. The heavy solids get settled at the bottom while oil, grease and lighter solids float over the surface. The settled and floating materials are removed. The remaining liquid undergoes secondary treatment.

Secondary treatment

Secondary treatment is used to remove the biodegradable dissolved organic matter. This is performed in the presence of oxygen by aerobic microorganisms (Biological oxidation). The microorganisms must be separated from treated water waste by sedimentation. After separating the sediments of biological solids, the remaining liquid is discharged for tertiary treatment.

Tertiary treatment

Tertiary or advanced treatment is the final step of sewage treatment. It involves removal of inorganic constituents such as nitrogen, phosphorus and microorganisms. The fine colloidal particles in the sewage water are precipitated by adding chemical coagulants like alum or ferric sulphate.



Uses of Recycled Water

- Agriculture
- Landscape
- Public parks
- Cooling water for power plants and oil refineries
- Toilet flushing
- Dust control
- Construction activities

IUCN (International Union for Conservation of Nature and Natural Resources)

IUCN is an international organization working in the field of nature conservation and sustainable use of natural resources. IUCN is the global authority on the status of the natural world and the measures needed to safeguard it.

Vision of IUCN

The vision of IUCN is 'A just world that values and conserves nature'.

Mission of IUCN

The mission of IUCN is to influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable.

The organization is best known to the wider public for compiling and publishing the IUCN red list of threatened species, which assesses the conservation status of species worldwide.

India, a mega diverse country with only 2.4 % of world's land area, accounts for 7-8% of all recorded species. It includes over 45,000 speciesof plants and 91,000 species of animals. The country's diverse physical features and climatic conditions have resulted in a variety of ecosystems such as forests, wetlands, grasslands, desert, coastal and marine ecosystems. Four of 34 globally identified biodiversity hotspots are found in India. They are:

- The Himalayas
- The Western ghats
- The North-East
- The Nicobar islands

India became state member of IUCN in 1969, through the Ministry of Environment, Forest and Climate change(MoEFCC).

IUCN was founded on 5th October 1948 at Gland, Switzerland.

10th Book

22.ENVIRONIMENTAL MANAGEMENT

Introduction

Environmental management deals with the different aspects of environment, its structure, function, its quality and its maintenance including conservation of its living and non-living components. The diversified natural resources on this earth provide the necessities for survival of all forms of life including man. Everything that comes from nature has some utility for man but its utilization is possible based on the availability of appropriate technology.

Resources can be renewed simultaneously along with their exploitation (forests, crops, wildlife, groundwater, wind and solar energy). They can maintain themselves by natural recycling or can be replenished by proper management. Simultaneously, non-renewable resources cannot be recycled and can get exhausted by unlimited and continous use (mineral ores, coal, petroleum etc). They cannot be replaced easily. This would lead to a situation where non-renewable resources may come to an end after a certain period of time.

Expanding human population resulted in expanding needs of man. With scientific and technological advancement man started utilizing natural resources at a much larger scale. Continuous increase in population caused an increased demand for resources. Therefore, conservation of natural resources makes important contributions to the social and economic development of the country.

Conservation and Judicious Use of Resources

Natural resources are conserved for their biological, economic and recreational values. The use of natural resources in excess and unplanned way leads to imbalance in the environment. A judicious balance should be maintained between exploitation of resources and its replenishment. Proper utilization andmanagement of nature and its resources is termed as conservation.

We have to build a sustainable world, which should last forever. Some of the ways to sustain continuous use of resources are practices to utilise energy efficiently, avoid wastage of water, avoid usage of plastics and other non-biodegradable materials and to take care for the environment we live. It is important that we manage and use our resources carefully so as to preserve for the future generations.

Forest and its Importance

Forests are an important component of our environment and are dominated by microorganisms, flowering plants, shrubs, climbers, dense trees and provide a vast habitat for wild animals. Forests also contribute to the economic development of our country. Forests are vital for human life, it is a source for a wide range of renewable natural resource. They provide wood, food, fodder, fibre and medicine.
Forests are major factor of environmental concern. They act as carbon sink, regulate climatic conditions, increase rainfall, reduce global warming, prevent natural

hazards like flood and landslides, protect wildlife and also act as catchments for water conservation. They also play a vital role in maintaining the ecological balance.

Deforestation and its Effects

Deforestation is the destruction of large area of forests. This happens for many reasons like intensive agriculture, urbanization, construction of dams, roads, buildings and industries, hydroelectric projects, forest fires, construction of mountain and forest roads. It is a threat to the economy, quality of life and future of the environment. India is losing about 1.5 million hectares of forest cover every year.

Effects of Deforestation

Deforestation gives rise to ecological problems like floods, drought, soil erosion, loss of wild life, extinction of species, imbalance of biogeochemical cycles, alteration of climatic conditions and desertification.

Conservation of Forests

India has an area of 752.3 lakh hectare classified as reserved forests and 215.1 lakh hectare as protected forests. The important measures taken for conservation of forests are as follows

Afforestation: Activities for afforestation programme (Van Mahotsav) includes planting and protecting trees with multiple uses which help in restoration of green cover. Destruction of trees should be curtailed.

Social forestry programme: It should be undertaken on a large scale with active participation of the public and utilization of common land to produce firewood, fodder and timber for the benefit of the rural community. This relieves pressure on existing forests and to safeguard future of tribals.

Forest Conservation through Laws: Adopting stringent laws and policies to conserve and protect forests are through National Forest Policy, (1952 and 1988) and Forest Conservation Act, 1980.

Wildlife and its Conservation

Wild life refers to the undomesticated animals living in their natural habitats (forests, grasslands and deserts) an area without human habitation. They are needed for maintaining biological diversity. It also helps in promoting economic activities that generates revenue through tourism. Conservation of forest and wildlife is interrelated with each other.

Decline in Wildlife Population

Wildlife of India is a great natural heritage. Exploitation of wildlife resources has decreased global wildlife population by 52% between 1970 and 2014. Over exploitation and shrinking of forest cover areas has resulted in animals becoming extinct, some arethreatened and some are on the verge of extinction. In recent years, increase in human encroachment has posed a threat to India's wildlife.

Aims of Wildlife Management

The main aimof wildlife conservation are:

- To control and limit exploitation ofspecies.
- To preserve the plants and animals fromextinction.
- Maintenance of threatened species andprotect species which are on the verge ofextinction.
- Preserve the endangered species.
- To study the ecological relationship ofthe plants and animals in natural habitat.
- Hunting and poaching should beprohibited.
- Establishment of National parks, Wildlifesanctuaries, protected areas and Biosphererereserves.

The Wildlife protection Act was established in 1972. The provisions of the act are

- Prohibit killing and hunting of specifiedanimals.
- Constitute sanctuaries, national parks,and closed areas for wildlife conservation.
- Special schemes for preservation ofendangered species.
- Constitute Central Zoo Authority andrecognition of zoos.
- Restrict, regulate or prohibit trade in wildanimals and products obtained from them.

No You Know?

- Jim Corbett National Parkwas the first to be establishedin 1936 in Uttarakhand, India.
- There are 15 biosphere reserves in India.
- The Nilgiris is a biosphere reserve inTamil Nadu.

Organisations Involved in Conservation of Wildlife

(i)Indian Board for WildLife (IBWL)
(ii)World Wildlife Fund (WWF) for Nature
(iii)World Conservation Union (WCN)
(iv)International Union for Conservation ofNature and Natural resources (IUCN)
(v)Convention of International Trade inEndangered Species (CITES)
(vi)Bombay Natural History Society
(vii)Wild life Preservation Society of India,Dehradun

Info bits

Wildlife Conservation Initiatives In India.

- Project Tiger and Project Elephant has been launched in 1973 and 1992 respectively
- Crocodile Conservation Project was launched in 1976.
- Sea Turtle Conservation Project was launched in 1999.
- Indian Rhino Vision 2020 is to conserve at least 3000 greater one-horned

rhinos in Assam, India by 2020.

Soil Erosion

The top layers of soil contain humus and mineral salts, which are vital for the growth of plants. Removal of upper layer of soil by wind and water is called soil erosion. Soil erosion causes a significant loss of humus, nutrients and decrease the fertility of soil.

Agents of Soil Erosion

Agents of soil erosion are high velocity of wind, air currents, flowing water, landslide, human activities (deforestation, farming and mining) and overgrazing by cattle.

Management of Soil Erosion

- Retain vegetation cover, so that soil is not exposed.
- Cattle grazing should be controlled.
- Crop rotation and soil management improve soil organic matter.
- Runoff water should be stored in the catchment.
- Reforestation, terracing and contour ploughing.
- Wind speed can be controlled by planting trees in form of a shelter belt.

Renewable and Non-Renewable Energy Resources

Energy is an important input for development. The expansion of possible energy resources has been directly related with the pace of agricultural and industrial development in every part of the world. Energy resources can be classified as non-renewable and renewable.

Non-renewable (Exhaustible) energy resources

Energy obtained from sources that cannot renew themselves over a short period of time is known as non-renewable energy. These are available in limited amount in nature. They include coal, petroleum, natural gas and nuclear power. These conventional energy resources account for 90% of the world's production of commercial energy and nuclear power account for 10%.

Renewable (Inexhaustible) energy resources

These energy resources are available in unlimited amount in nature and they can be renewed over a short period of time, inexpensive and can be harvested continuously. These comprise the vast potential of non-conventional energy resources which include biofuel, biomass energy, geothermal energy, water energy (hydroelectric energy and tidal energy), solar energy, wave energy and wind energy.

Fossil Fuels

Fossil fuels are found inside the earth's crust and are energy rich substances formed by natural process, such as anaerobic decomposition of buried dead organisms, over millions of years. As the accumulating sediment layers produce heat

and pressure, the remains of the organisms are gradually transformed into hydrocarbons. e.g. petroleum, coal and natural gas.

Coal and Petroleum

Coal and Petroleum are natural resources. They are called fossil fuels as they are formed from the degradation of biomass buried deep under the earth millions of years ago.

No You Know?

India is the third largest consumer of crude oil in the world, after the United States and China.

Coal is used for generation of electricity at Thermal power plants. Petroleum also known as crude oil is processed in oil refineries to produce petrol and diesel which are used to run automobiles, trucks, trains, ships and airplanes etc. Kerosene and LPG (Liquefied Petroleum Gas) obtained from petroleum is used as domestic fuel for cooking food.

The coal and petroleum reserves can get exhausted if we continue using them at a rapid rate. The formation of these fossil fuels is a very slow process and takes very long period of time for renewal.

Steps to Conserve Coal and Petroleum Resources

It is necessary to conserve or save coal and petroleum resources for the future use, which can be done by reducing their consumption.

(i)If electricity is saved,it willinturnreducethe use of coal
(ii)Using bicycle for covering short distancesinstead of using cars, scooters ormotorcycles
(iii)Using pressure cooker can reduce theconsumption of kerosene and LPG whilecooking food. Solar cooker and solarheaters can be used wherever possible
(iv)Motor vehicles should be designed withfuel efficient engines to increase efficiencyand also reduce air pollution

Case study of TajMahal

The TajMahal is one of the seven wonders of the world and is located in Agra, Uttarpradesh. It is built with white marble. The Mathura oil refinery owned by Indian Oil Corporation present around this area produce sulphur and nitrogen oxides. The white marble became yellow due to air pollution. The Government of India has set up emission standards around the monument to protect it from the damage.

Non-Conventional (Alternative) Energy Resources

The energy crisis has shown that for sustainable development in energy sector we must conserve the non-renewable conventional resources from its rapid depletion and replace them by non-polluting, renewable sources which are environmentally clean.

Efforts are made to develop new sources of energy which is called non-conventional sources of energy. It would provide greater initiative to local people who could assess their needs and resources and plan a strategy that could be useful to them.

Solar Energy

Solar energy is the energy obtained from the sun. The sun gives out vast amount of light and heat. It is only a little less than half (47 %) of solar energy which falls on the atmosphere reaches the earth's surface. If we could use just a small part of this energy it would fulfill all the country's need for power. Solar energy has advantages and also certain limitations.

Solar Energy Devices

The energy from the sun can be harnessed to provide power. The various devices used for harnessing sun's energy are called solar energy devices.

Solar Cells

Solar cells (Photovoltaic devices) is made up of silicon that converts sunlight directly into electricity. Solar cell produces electricity without polluting the environment. Since it uses no fuel other than sunlight, no harmful gases, no burning and no wastes are produced. These can be installed in remote and inacessible areas (forests and hilly regions) where setting up of power plant is expensive.

Uses of Solar cells

(i)It can be used for street lighting, traffic signals, water pumping, battery charging system etc.

(ii) It is used in artificial satellites and space probes

(iii) It provides radio and TV transmission to remote areas

(iv)It is used in calculators, electronic toys and watches.

Solar Panel

Arrangement of many solar cells side by side connected to each other is called solar panel. Th e capacity to provide electriccuurent is much increased in the solar panel. But the process of manufacture is very expensive. Figure

Solar Panel Solar Cooker

It consist of an insulated metal box or wooden box which is painted from inside so as to absorb maximum solar radiations. A thick glass sheet forms the cover over the box. The reflector is the plane mirror which is attached to the box. Th e food is cooked by energy radiated by the sun.

Solar thermal power plant

In solar thermal power plants, many solar panels are used to concentrate sun rays, to heat up water into steam. Th e steam is used to run the turbines to produce electricity.

No You Know?

A capacity of 100 litres solar heater can save upto 1500 units of electricity per year.

Advantages of Solar Energy

(i) It is available in abundance in our country and is free of cost.
(ii) It is a renewable source of energy.
(iii) It can be used for generating electricity or heat.
(iv)It does not cause pollution.

22.6.2 Biogas

Biogas is the mixture of methane (nearly 75 %), hydrogen sulphide, carbon dioxide and hydrogen. It is produced by the decomposition of animal wastes (cow dung) and plant wastes in the absence of oxygen. It is also commonly called as 'Gobar gas' since the starting material used is cow dung which means gobar in Hindi.

Uses of biogas

(i) It is used as fuel for cooking .
(ii) It is used to run motors and pump sets.
(iii) It is used to generate electricity.

Advantages of biogas

(i)It burns without smoke and therefore causes less pollution.
(ii)An excellent way to get rid of organic wastes like bio-waste and sewage material.
(iii) Left over slurry is agood manure rich in nitrogen and phosphorus
(iv)It is safe and convenient to use (v)It can reduce the amount of greenhouse gases emitted.

22.6.3 Shale gas

Shale refers to the soft finely stratified sedimentary rock that is formed from the compaction of small old rocks containing mud and minerals – such as quartz and calcite, trapped beneath earth's surface. These rocks contain fossil fuels like oil and gas in their pores.

The fuel is extracted by a technique called hydraulic fracturing (drilling or well boring of sedimentary rocks layers to reach productive reservoir layers).

Environmental concerns of shale gas

(i)Shale drilling could affect groundwaterreserves, which can contaminate thedrinking water resources and also affectthe fertility of the soil.

(ii)Million gallons of water is needed tobreak and release the shale gas, whichinturn can affect the water table.

More to Know?

India has identified six basins as areas for shale gas exploration: Cambay (Gujarat), Assam-Arakan (North East), Gondwana (Central India), Krishna Godavari onshore (East Coast), Cauvery onshore and Indo-Gangetic basins.

Wind Energy

The kinetic energy possessed by the wind is due to its high speed, that can be converted into mechanical power by wind turbines. The wind energy can be used for (i) generating electricity (ii) Run water pumps, flour mills etc. (iii) Rotatory motion of windmill is used to draw water from wells.

No You Know?

- The world's largest and tallest wind turbine is situated in Hawaii.
- One wind turbine can produce electricity for 300 homes.

Windmill

Windmill is a machine that converts the energy of wind into rotational energy by broad blade attached to the rotating axis. When the blowing air strikes the blades of the windmill, it exerts force and causes the blades to rotate. The rotational movement of the bladesoperate the generator and the electricity is produced. The energy output from each windmill is coupled together to get electricity on a commercial scale.

Advantages of Wind energy

(i)Wind energy is free, eco-friendly,renewable source of energy.
(ii)It does not cause pollution.
(iii)Expenseson periodicmaintenance is lowwhen compared to the other power sources.

Water Energy

Earth's surface is covered with nearly 71 % of water. Harnessing the energy from the flowing water can be used to produce electricity. The technique to harness the water energy is called Hydropower.

The electrical energy is derived from water flow, water falling from a height. Hilly areas are suitable for this purpose where there is continous flow of water in large amounts falling from high slopes. It does not cause environmental pollution or waste generation.

Hydropower plants converts the kinetic energy of flowing water into electricity. This is called hydroelectricity.

Tidal Energy

Tidal energy is the energy obtained from the movement of water due to ocean tides. Tides are the rise and fall of sea levels caused by the combined effects of the gravitational forces exerted on the oceans of the earth.

A tidal stream is a fast flowing body of water created by tides. Turbines are placed in tidal streams. When the tides hit the turbine, the turbine rotates and converts the tidal energy into electric energy

Advantages of tidal energy

(i) Tidal energy does not produce any pollution.
(ii) It does not use any fuel and does not produce any waste.
(iii) Tides are predictable, so tidal energy can be produced at any time.
(iv) Water is denser than air and therefore can generate electricity at lower speeds than wind turbines.

Rainwater Harvesting

Rainwater harvesting is a technique of collecting and storing rainwater for future use. It is a traditional method of storing rain water in underground tanks, ponds, lakes, check dams and used in future.
The main purpose of rainwater harvesting is to make the rainwater percolate under the ground so as to recharge 'groundwater level'.

Methods of rainwater harvesting

(i) Roof top rainwater harvesting: Roof-tops are excellent rain catchers. The rain water that falls on the roof of the houses, apartments, commercial buildings etc. is collected and stored in the surface tank and can be used for domestic purpose.
(ii) Recharge pit: In this method, the rainwater is first collected from the roof tops or open spaces and is directed into the percolation pits through pipes for filtration. After filtration the rainwater enters the recharge pits or ground wells.

People living in rural areas adopt a variety of water collecting methods to capture and store as rain water. Some of the methods used are
(i) Digging of tanks or lakes (Eris): It is one of the traditional water harvesting system in Tamil Nadu. Eris are constructed in such a way that if the water in one eri overflows, it automatically gets diverted to the eri of the next village, as these eris are interconnected.
(ii) **Ooranis:** These are small ponds to collect rainwater. The water is used for various domestic purposes (drinking, washing and bathing). These ponds cater the nearby villages.

Advantages of rainwater harvesting

Rainwater harvesting helps to

More to Know?
kallanai Dam, also known as Grand Anicut, is the fourth oldest dam in the world, constructed by King KarikalaChola of the Chola Dynasty in the 2nd century A.D.(CE). It still serves the people of Tamilnadu, The dam is located on the River Kaveri, approximately 20 km from the city of Tiruchirapalli.

(i)Overcome the rapid depletion of groundwater levels.
(ii)To Meet the increase demand of water.
(iii)Reduces flood and soil erosion
(iv)Water stored in ground is not contaminatedby human and animal wastes and hencecan be used for drinking purpose.

Electrical Energy Management

Electricity or electric power is produced by generators. The generators are operated by the turbines attached to it. The turbines are rotated by steam, moving water or wind power to produce electricity.

Conservation of electrical energy

The following measures can be taken even at home and school to save electricity

(i)Use energy efficient appliances to saveelectricity like Compact FluorescentLamps (CFL), Light Emiting Diode (LED)bulbs and other electric equipments.

(ii)Switch off the lights and fans, televisionand other electrical appliances when notin use.

(iii)Switch of the mobile phone chargerswhen not in use.

(iv)Maximise the use of solar radiation. Solarwater heating system can be used insteadof electric geysers.

(v)Minimise the use of air conditioners.

E-Wastes and its Management

E-wastes are generally called as electronicwastes, which includes the spoiled, outdated, non-repairable electrical and electronic devices. These wastes contain toxic metals like lead, cadmium, chromium and mercury, though also contain iron, copper, silicon, aluminum and gold which can be recovered. Neverthless, only 5 % of e-wastes produced are recycled.

Sources of e-wastes

Electronic devices: Computers, laptops, mobile phones, printers, monitors, televisions, DVD players, calculators, toys, sport equipments, etc.

Household electrical appliances: Refrigerators, washing machine, microwave oven, mixer, grinder, water heater, etc.

Accessories: Printing cartridges, batteries and chargers.

E-wastes include
Computer components -66%
Telecommunication components - 12 %
Electronic components -5 %
Biomedical components -7 %
Other components -6 %

Environmental impact of e-wastes

Disposal of any kind of electrical and electronic devices without knowledge can become the landfill and water pollutants.

Electronic equipments contain many hazardous heavy metals such as lead, cadmiumthat can cause severe soil and groundwater pollution.

E-waste dumping yards and the places nearby are polluted and cause severe health hazard.

Sewage Management

Untreated sewage or wastewater generated from domestic and industrial process is the leading polluter of water sources in India. Sewage water results in agricultural contamination and environmental degradation.

Sources of Sewage/wastewater

- Domestic purpose or household activities
- Dye and textile industries
- Leather industries
- Sugar and breweries industries
- Paper and pulp industries

Sewage/wastewater treatment method

The conventional wastewater treatment methods involve the following steps **(a) Pre-screening (b) Aeration (c) Sludge Management and (d) Water Reuse.**

Pre-screening: Wastewater generated from domestic and industrial activities is screened to remove soil and solid particulates.

Aeration: Screened wastewater is then pumped to an aeration tank. Here the microbial contaminants are removed by the biological degradation that occurs in the presence of air.

Sedimentation process: In this process, the solid particles in suspension form are allowed to settle. The particles that settle out from the suspension is known as sludge.

Sludge removal: The sludge generated by the degradation process is transferred periodically from the tank for safe disposal.

Disinfection: Chlorination and ultraviolet (UV) radiation of treated water is required to remove any microorganism contamination.

Water recycling: The water will then be supplied for domestic or industrial purposes.

Solid Waste Management

Solid wastes mainly include municipal wastes, hospital wastes, industrial wastes and e-wastes etc. The solid wastes are dumped in the soil which results in landscape pollution.

Solid-waste management involves the collection, treatment and proper disposing of solid material that is discarded from the household and industrial activities.

Methods of solid wastes disposal

(i)**Segregation:** It is the separation of differenttype of waste materials like biodegradableand non biodegradable wastes.

(ii)**Sanitary landfill:** Solid wastes are dumpedinto low lying areas. The layers arecompacted by trucks to allow settlement.The waste materials get stabilised in about2-12 months. The organic matter undergoesdecomposition.

(iii)Incineration: It is the burning of nonbiodegradable solid wastes (medicalwastes) in properly constructed furnace athigh temperature.

(iv)Composting: Biodegradable matter ofsolid wastes is digested by microbial actionor earthworms and converted into humus.

Recycling of wastes

- Papers from old books, magazines andnewspapers are recycled to produce papersin papermills.
- Agricultural wastes like coconut shells, jutecotton stalk, bagasse of sugarcane can beused to make paper and hard board. Paddyhusk can be used as livestock fodder.
- Cowdung and other organic wastes can beused in gobar gas plant to provide biogasand manure for fields.

3R Approach

The 3R approach such as Reduce, Reuse and Recycle may be followed for effective waste management.

12th zoology
11. Organisms and Population

The word 'ecology' is derived from the Greek term 'oikos', meaning 'house' and logos, meaning 'study'. Thus, the study of the environmental 'house' includes all the organisms in it and all the functional processes that make the house habitable.The study of ecology encompasses different levels-organism, population, community, ecosystem, etc., In ecology, the term population, originally coined to denote a group of people is broadened to include groups of individuals of any one kind of organism. Community in the ecological sense (designated as 'biotic community') includes all the populations occupying a given area.

The community (Biotic) and the non-living environment (Abiotic) function together as an ecological system (or) ecosystem. Biome is a term in wide use for a large regional or sub continental system characterized by a major vegetation type. The largest and most nearly self-sufficient biological system is often designated as the Ecosphere, which includes all the living organisms of the Earth, interacting with the physical environment to regulate their distribution, abundance, production and evolution.

Organism and its environment

Every living organism has its own specific surrounding, medium or environment with which it continuously interacts and develops suitable adaptations for survival there. Environment is a collective term which includes the different conditions in which an organism lives or is present. The common and influencing factors in any environment are light, temperature, pressure, water, salinity. These are collectively referred to as Abiotic components. Environments are variable and dynamic, in which temperature changes and light changes are diurnal and seasonal. These influence the organisms inhabiting them. An organism's growth, distribution, number, behaviour and reproduction is determined by the different factors present in the environment.

Habitat

A habitat can be considered as the 'address' of the organism. The collection of all the habitat areas of a species constitutes its geographical range. Organisms in a habitat interact with each other and can be part of trophic levels to form food chains and food webs. Examples: In a xerophytic habitat, the camel is able to use water efficiently and effectively for evaporative cooling through their skin and respiratory system. They excrete highly concentrated urine and can also withstand dehydration upto 25% of the body weight. The hoofs and hump are also suitable adaptations for survival in this dry sandy environment.

In an aquatic media, maintaining homeostasis and osmotic balance is a challenge. So, marine animals have appropriate adaptations to prevent cell

shrinkage. While freshwater organisms have suitable adaptations to withstand bursting of their cells. Apart from this, organisms such as fish have a wide range of adaptations like fins (locomotion), streamlined body (aerodynamic), lateral line system (sensory), gills (respiration), air sacs (floatation) and kidneys (excretion).

Niche (or) Ecological Niche

As every organism has its unique habitat, so also it has an ecological niche which includes the physical space occupied by an organism and its functional role in the community. The ecological niche of an organism not only depends on where it lives but also includes the sum total of its environmental requirements. Charles Elton (1927) was the first to use the term 'niche' as the functional status of an organism in its community. Groups of species with comparable role and niche dimensions within a community are termed 'guilds'. Species that occupy the same niche in different geographical regions, are termed 'ecological equivalents'.
Many animals share the same general habitat. But their niches are well defined. The life style of an individual population in the habitat is known as its niche. For example, crickets and grasshoppers are closely related insects that live in the same habitat, yet they occupy different ecological niches.

The grasshopper is very active during daylight. It can usually be found on a plant, feeding on the plant parts. Although the cricket lives in the same field, it is quite different. During the day, the cricket hides under leaves or plant debris and is usually inactive. It is active at night time (nocturnal). The cricket and the grasshopper do not interfere with each other's activities in the same habitat. Thus, niche of an organism can be defined as the total position and function of an individual in its environment. In a pond ecosystem, where Catla, Rohu and Mrigal are present, the ecological niche of the Catla is a surface feeder, Rohu is a column feeder and Mrigal is a bottom feeder. Their mouths are designed to suit their niche and hence have different positions and functions in their habitat. (Fig.11.1)

Major Abiotic Components or Factors

The abiotic factors include the chemical and physical factors which influence or affect organisms and their functioning in their environment. The common abiotic factors are:

Temperature

Temperature or degree of hotness and coldness is an essential and variable factor in any environment. It influences all forms of life by affecting many vital activities of organisms like metabolism, behaviour, reproduction, development and even death in the Biosphere. The minimum and maximum temperature of an environment regulates the survival of a cell.

Van't Hoff's rule

Van't Hoff proposed that, with the increase of every 10°C, the rate of metabolic activity doubles or the reaction rate is halved with the decrease of 10°C. This rule is referred as the van't Hoff's rule. The effect of temperature on the rate of reaction is expressed in terms of temperature coefficient or Q10 value. The Q10 values are estimated taking the ratio between the rate of reaction at X°C and rate of reaction at (X-10°C). In the living system the Q10 value is about 2.0. If the Q10 value is 2.0, it means 10°C increase and the rate of metabolism doubles.

The metabolism of organisms is regulated by enzymes which are temperature sensitive. In many organisms, determination of sex and sex ratio, maturation of gonads, gametogenesis and reproduction is influenced by temperature. In certain environments, the size and colouration of animals are influenced by temperature. Birds and mammals attain greater body size in colder regions than warmer regions (Bergmann's rule). Warm blooded animals, living in colder climates, tend to have shorter limbs, ears and other appendages when compared to the members of the same species in warmer climates (Allen's rule).

In some aquatic environments, an inverse relationship between water temperature and fish meristic characters is observed - lower the temperature, more the vertebrae (Jordon's rule). Temperature influences the distribution of organisms. The tropics have higher diversity and density of populations, when compared to temperate and Polar Regions.

Adaptations to temperature

Adaptation to temperature is essential for the survival of the species/organisms. Organisms which can survive a wide range of temperature are referred to as Eurytherms(cat, dog, tiger, human). Eurythermy can be an evolutionary advantage: adaptations to cold temperatures (cold-eurythemy) are seen as essential for the survival of species during ice ages. In addition, the ability to survive in a wide range of temperatures increases a species' ability to inhabit other areas, an advantage for natural selection. Eurythermy is an aspect of thermoregulation in organisms. Those organisms which can tolerate only a narrow range of temperature are Stenotherms (Fish, Frogs, Lizards and Snakes).

Over the course of time, by evolution, animals of different ecological habitats have developed different variations and adaptations to temperature changes. It enabled them to survive in different habitats and develop niches. In case of extreme temperatures, organisms have adapted by forming heat resistant spores, cysts (Entamoeba), antifreeze proteins (Arctic fishes). Hibernation (winter sleep) and Aestivation (Summer sleep) are useful adaptations to overcome extreme winters and summers. In certain conditions, migration is an appropriate adaptation to overcome extreme temperatures and resultant water and food scarcity. (Fig 11.2).

Light

It is an important and essential abiotic factor. Ecologically, the quality (wavelength or colour), the intensity (actual energy in gramcalories) and duration (length of day) of light are considered significant for organisms. Light influences growth, pigmentation, migration and reproduction. The intensity and frequency of light influences metabolic activity, induce gene mutations (UV, X- rays). Light is essential for vision. This is proved by the poorly developed or absence of eyes in cave dwelling organisms. Diapause is also influenced by light in animals. Gonads of birds become more active with increasing lightin summer. Light influences the locomotion and movement of lower animals.

- **Phototaxis:** The movement of organism in response to light, either towards the source of light as in Moths (positive phototaxis) or away from light (Euglena, Volvox, earthworm (negative phototaxis).
- **Phototropism:** The growth or orientation of an organism in response to light, either towards the source of light (positive phototropism) as seen in Sunflower, or a way from light (negative phototropism) as in case of the root of plants.
- **Photokinesis:** A change in the speed of locomotion (or frequency of turning) in a motile organism or cell which is made in response to a change in light intensity is called Photokinesis. It involves undirected random movement in response to light.

Water

Life on earth began in the seas and water is essential for the survival of all forms of life. About three-fourth of the earth's surface is covered with water (hydrosphere). Water is found in three states: gaseous, liquid, and solid. There are two types of water on Earth. They are the Fresh water (rivers, lakes, ponds) and the Salt water (seas and oceans). Based on the dissolved salts, water can be hard water (sulphates/nitrates of Calcium/Magnesium) or soft water. If hardness can be removed by boiling, it is temporary hard water, and if boiling does not help, it is permanent hard water.

Essential properties of water

- Water is one of the main agents in Pedogenesis (soil formation).
- It is the medium for several different ecosystems.
- It is present as moisture in the atmosphere and the outer layers of the lithosphere and is uneven in distribution on the earth.
- Water is heavier than air and imparts greater buoyancy to the aquatic medium. This enables organism to float at variable levels.
- Water has high heat capacity and latent heat, due to which it can withhold large amounts of heat. Thus, oceans and lakes tend to maintain a relatively constant temperature, and the biosphere is relatively thermostable.

- Water is physically unique because it is less dense as a solid (ice) than as a liquid.
- When water freezes (0^0C), it contracts. The maximum density of liquid water occurs at 4^oC. Below that, it expands markedly. This enables ice to float on the top of water bodies. Hence, only the surface of water bodies will freeze, while below the surface, water will be in liquid form, sustaining life (Fig. 11.3).
- Water is considered as the Universal solvent. It is the main medium by which chemical constituents are transported from abiotic components to the living components of an ecosystem.
- Water has high surface tension. This allows pollen, dust, and even water striders to remain at the surface of a water body even though they are denser than the water.

Soil

It is a mixture of organic matter, minerals, gases, liquids and organisms that together support life. The soil zone is known as Pedosphere. Soil is formed from rocks which are the parent materials of soil, by weathering and is called embryonic soil (Pedogenesis). It has four major functions-

- medium for plant growth
- means for water storage and purification
- modifier of earth's atmosphere
- habitat for many organisms, which in turn modify the soil

Soil is formed of many horizontal layers called as Soil Profile.

Properties of Soil

1. **Texture of soil:** The texture of soil is determined by the size of the soil particles. The types of soil include sand, silt and clay on the basis of their size differences.

2. **Porosity:** The space present between soil particles in a given volume of soil are called pore spaces. The percentage of soil volume occupied by pore space or by the interstitial spaces is called porosity of the soil.

3. **Permeability of soil**: The characteristic of soil that determines the movement of water through pore spaces is known as soil permeability. Soil permeability is directly dependent on the pore size. Water holding capacity of the soil is inversely dependent on soil porosity.

4. **Soil Temperature**: Soil gets its heat energy from solar radiation, decomposing organic matter, and heat from the interior of earth. Soil

temperature effects the germination of seeds, growth of roots and biological activity of soil-inhabiting micro-and macro-organisms.

5. **Soil water:** In soil, water is not only important as a solvent and transporting agent, but also maintains soil texture, arrangement and compactness of soil particles, making soil habitable for plants and animals.

Wind

Wind is the natural movement of air of any velocity from a particular direction. The two main causes are differential heating between the equator and the poles and the rotation of the planet (Corioliseffect). Wind helps to transport pollen grains, seeds, and even flight of birds. While it is the source of wind energy, it also causes erosion. Wind speed is measured with an Anemometer.

Humidity

Moisture in the form of invisible vapor in the atmosphere is called humidity. which is generally expressed in terms of absolute humidity, relative humidity or specific humidity. Absolute humidity is the total mass of water vapour present in a given volume or mass of air. It does not take temperature into consideration.

Relative humidity is the amount of water vapour present in air and is expressed as a percentage of the amount needed for saturation at the same temperature Relative humidity is expressed as a percentage; a high percentage means that the air-water mixture is more humid at a given temperature. Humidity is measured with a Hygrometer.

Altitude

This factor is mainly the elevation or gradient and it affects temperature and precipitation in an ecosystem or biome. As altitude increases, temperature and density of oxygen decreases. Higher altitudes usually receive snow instead of rain because of low temperature.

Animals are known to modify their response to environmental changes (stress) in reasonably short time spans. This is known as Acclimatization. This is observed when people who have moved from the plains to higher altitudes show enhanced RBC count within a few days of settling in their new habitat. This helps them cope with lower atmospheric oxygen and higher oxygen demand.

Concept of biome and their distribution

Biomes are large regions of earth that have similar or common vegetation and climatic conditions. They play a crucial role in sustaining life on Earth. They are

defined by their soil, climate, flora and fauna. Biomes have distinct biological communities that have been formed in response to a shared physio-chemical climate. Biomes are seen to even spread across continents. Thus, it can be observed that a biome is a broader term than habitat. Any biome can comprise a variety of habitats. Factors such as temperature, light, water availability determine what type of organisms and adaptations are observed in a biome (Fig. 11.4).

Characters of a biome

- Location, Geographical position (Latitude, Longitude)
- Climate and physiochemical environment
- Predominant plant and animal life
- Boundaries between biomes are not always sharply defined. Transition or transient zones are seen as in case of grassland and forest biomes. (Fig. 11.5)

Aquatic Biomes: They occupy about 71% of the biosphere. The aquatic biome is home to millions of aquatic organisms like fishes. The climate of coastal zones is influenced by aquatic bodies. (Fig. 11.6).

Aquatic biomes of earth

1. Freshwater (Lakes, ponds, rivers)
2. Brackish water (Estuaries / Wetlands)
3. Marine (Coral reefs, pelagic zones and abyssal zones)

Terrestrial biomes

These are large communities of plants and animals that occupy a distinct region. They include grassland, tundra, desert, tropical rainforest, and deciduous and coniferous forests. Terrestrial biomes are distinguished primarily by their predominant vegetation, and are mainly determined by climate, which in turn, determines the organisms inhabiting them. These include the keystone species and indicator species which are unique to their respective biomes. The terrestrial biomes are a source of food, O2 and act as CO2 sink, apart from the climate regulatory role. (Fig. 11.7).

Major Biomes of the Earth

Tundra biome, Taiga biome, Grassland biome, Alpine biome, Forest biome and Desert biome.

TUNDRA BIOME

- This is the almost treeless plain in the northern parts of Asia, Europe and North America.

- Winters are long with little daylight, Summers are short, with long daylight hours.
- Precipitation is less than 250 mm per year. It is a zone of permafrost.
- Dwarf willows, birches, mosses, grasses, sedges are the fora here.
- Reindeer, arctic hare, musk ox, lemmings are important Tundra herbivores. Some important carnivores are the arctic fox, arctic wolf, bobcat and snowy owl. Polar bears live along coastal areas.
- Because of the severe winters, many of the animals are migratory. For example, the many shore birds and waterfowl such as ducks and geese, nest in the Tundra during the summer and migrate south for the winter.

Do you know?

Historically biomes are known to move as climate changes. A classic example is the Sahara Desert, which years ago were supposed to be a lush landscape with river flowing through it. Accordingly appropriate fauna like Hippos, Giraffes, and Crocodiles lived amid abundant trees. Over course of time the climate dried out. It has now become the planets largest desert. The animals have migrated out to adjacent regions with more favourable conditions.

Characteristics of Tundra:

- Extremely cold climate
- Low biotic diversity
- Simple vegetation structure
- Limitation of drainage
- Short season of growth and reproduction
- Energy and nutrients in the form of dead organic material
- • Large population oscillations

TAIGA BIOME

- The Taiga is 1300-1450 km wide zone southof the Tundra.
- This area has long and cold winters.
- Summer temperature ranges from 10^0 C to 21^0 C.
- Precipitation ranges about 380-1000 mm annually.
- The Taiga is a forest of coniferous trees such as spruce, fir and pine. This is a major source for the logging industry.
- Important migratory herbivores include moose, elk, deer and reindeer. Moose and reindeer migrate to the Taiga for winter and to the Tundra for summers. The common smaller mammals are herbivorous squirrels, snowshoehare and predatory pine martens. Important predators include the timber wolf, grizzly bear, black bear, bobcat and wolverines. (Fig. 11.8)

GRASSLAND BIOME

- Grasslands occur in temperate and in the tropical regions.
- They have hot summers, cold winters, andirregular rainfall.
- Often they are characterized by high winds.
- The low irregular rainfall is the factor which makes the difference between a temperate deciduous forest and a temperate grassland.
- Herbivores like antelope, bison, wild horse,jack rabbit, ground squirrel and prairie dogsare abundant.
- Predators include coyotes, foxes, hawks andsnakes.
- In India, fauna of grasslands includesElephant, Gaur, Rhino, Antelope.
- Flora of grasslands include purple needle grass, wild oats, foxtail, ryegrass and buffalograss (Fig. 11.9).

Alpine biome

- The alpine zone (zone between timber line and snow zone) includes in the descending order, a sub-snow zone immediately below the snow zone, a meadow zone in the centre and a shrub zone which gradually merges into the timber zone.
- The snow zone of Himalayas lies over 5100m above mean sea level and alpine zone exists at a height of 3600m. From an ecological view point, the zone above the limits of tree growth (timber line) exhibits extreme environmental conditions which greatly influence the biota of this region.
- Alpine zone of Himalayas is characterized by sparseness of animal groups. Many invertebrates of alpine zone are predatory and occur in lakes, streams and ponds. Among fishes, amphibians and vertebrates are totally lacking and reptilian fauna is greatly impoverished.
- Flora of alpines includes alpine phacelia, bear grass, bristlecone pine, moss campion, polylepis forest, pygmy bitterroot, and wild potato.

Forest biomes

Forest is a broad term used to describe areas where there are a large number of trees (Fig. 11.10). The forest biomes include a complex assemblage of different kinds of biotic communities. The major forest biomes are the Tropical forests and the Temperate forests.

Tropical forest

- They occur near the equator (between latitudes 23.5^0 at north and 23.5^0 at south).
- The major characteristic of tropical forests is their distinct seasons. Only two seasons are present (rainy and dry). Winter is absent. The length of daylight is about 12 hours and varies little.

- The average annual temperature ranges between 20° C and 25° C.
- Precipitation is evenly distributed throughout the year with annual rainfall exceeding 2000 mm.
- Soil is nutrient-poor and acidic. Decomposition is rapid and soils are subject to heavy leaching.
- Tree canopy is multilayered and continuous, allowing little light penetration.
- Flora is highly diverse: one square kilometer may contain as many as 100 different tree species. Trees are 25-35 m tall, with buttressed trunks and shallow roots, mostly evergreen, with large dark green leaves. Common vegetation are orchids, bromeliads, vines (lianas), ferns, mosses, and palms.
- They are characterized by the greatest diversity of fauna which includes birds, bats, small mammals, and insects.

Based on the seasonal distribution of rainfall, the types of tropical forests are

- **Evergreen rainforest**: no dry season.
- **Seasonal rainforest**: short dry period in a very wet tropical region.
- **Semi evergreen forest**: longer dry season (the upper tree storey consists of deciduous trees, while the lower storey is still evergreen).
- **Moist/dry deciduous forest (monsoon)**: the length of the dry season increases further as rainfall decreases (all trees are deciduous).

More than half of earth's tropical forests have already been destroyed.

Temperate forest

- These forests occur in eastern North America, northeastern Asia and western and central Europe.
- Have well-defined seasons with a distinct winter. Moderate climate and a growing season of 140-200 days during 4-6 frost-free months distinguish temperate forests.
- Annual temperature varies from -30° C to 30° C.
- Precipitation (750-1500 mm) is distributed evenly throughout the year.
- Soil is fertile, enriched with decaying litter.
- Canopy is moderately dense and allows light to penetrate, resulting in well-developed and richly diversified understorey vegetation and stratification of animals.
- Flora is characterized by 3-4 tree species per km2. Trees have broad leaves that are lost annually such as oak, hickory, beech, hemlock, maple, basswood, cottonwood, elm, willow, and spring-flowering herbs.
- Fauna consists of squirrels, rabbits, skunks, birds, deer, mountain lion, bobcat, timber wolf, fox, and black bear.

Based on seasonal distribution of rainfall, the types of temperate forests are

- **Moist conifer and evergreen broad-leaved forests**: wet winters and dry summers.
- **Dry conifer forests**: dominate higher elevation zones; low precipitation.
- **Mediterranean forests:** precipitation is concentrated in winter (<1000 mm /year).
- **Temperate coniferous forests**: mild winters, high annual precipitation (> 2000 mm /year).
- **Temperate broad-leaved rainforests:** mild, frost-free winters, high precipitation (> 1500 mm/year), evenly distributed throughout the year.

Only scattered remnants of original temperate forests remain today.

Desert biomes

- Deserts cover about one fifth of the earth's surface and occur where rainfall is >500 mm/year.
- Rainfall is usually very low and/or concentrated in short bursts between long rainless periods. Evaporation rates regularly exceed rainfall rates.
- Soils are course-textured, shallow, rocky or gravely with good drainage and have no subsurface water. The finer dust and sand particles are blown elsewhere, leaving heavier pieces behind. Sand dunes are common.

- Mean annual temperatures range from 20-25° C. The extreme maximum ranges from 43.5 - 49° C. Minimum temperatures sometimes drop to -18° C. Based on the temperature range, deserts can be Hot deserts and Cold deserts.
- Hot deserts such as the Sahara of North Africa and the deserts of the southwestern U.S., Mexico, Australia and India (Thardesert) occur at low latitudes.
- Hot deserts have a considerable amount of specialized vegetation (xerophytes), aloe, agave, Opuntia species, Euphorbiaroyleana as well as specialized vertebrate and invertebrate animals.
- Soils often have abundant nutrients because they need only water to become very productive and have little or no organic matter.
- Only animals which can tap available water or capable of storing sufficient water and withstand the heat can survive in the desert. The animals include small nocturnal (active at night) carnivores. The dominant animals are burrowers and have cursorial, fossorial and saltatorial adaptations.
- The animals stay inactive in protected hideaways during the hot day and come out to forage at dusk, dawn or at night, when the desert is cooler.
- The dominant animals of warm deserts are reptiles and small mammals. The Indian Spiny-tailed lizard, the blackbuck, the white-footed fox are the common fauna of the Thar deserts. There are also insects, arachnids and birds (Fig. 11.11).

Do you know?

Rainfallis lowest in the Atacama Desert of Chile, where it averages less than 15 mm. Some years are even rainless. Inland Sahara also receives less than 15 mm rainfall a year. Rainfall in American deserts is higher — almost 280 mm a year.

1. **Cold deserts** are characterized by cold winters with snowfall and high overall rainfall throughout the winter and occasionally over the summer.
2. They occur in the Antarctic, Greenland and the Nearctic realm, parts of USA and in parts of western Asia and the Ladakh region in India.
3. They have short, moist, and moderately warm summers with fairly long, cold winters. The mean winter temperature is between -2° C and 4° C and the mean summer temperature is between 21° C and 26° C.
4. Winters receive quite a bit of snow. The mean annual precipitation ranges from 150-250 mm.
5. The soil is heavy, silty and salty.
6. Widely distributed animals are jack rabbits, kangaroo rats, kangaroo mice, pocket mice, grasshopper mice, antelope and ground squirrels.

Responses to Abiotic Factors

Every living organism responds to its environment. There are various ways by which organisms respond to abiotic conditions. Some organisms can maintain constant physiological and morphological conditions or undertake steps to overcome the environmental condition, which in itself is a response (Fig. 11.12).

The types of responses observed are

1. **Regulate**: Some organisms are able to maintain homeostasis by physiological means which ensures constant body temperature, ionic / osmotic balance. Birds, mammals and a few lower vertebrate and invertebrate species are capable of such regulation.

2. **Conform:** Most animals cannot maintain a constant internal environment. Their body temperature changes with the ambient temperature. In aquatic animals like fishes, the osmotic concentration of the body fluids changes with that of the ambient water osmotic concentration. Such animals are called Conformers. In case of extreme condition, the inhabitants relocate themselves as in migration.

3. **Migrate:** Organisms tend to move away temporarily from a stressful habitat to a new, hospitable area and return when the stressful period is over. Birds migrate from Siberia to Vedanthangal in Tamilnadu to escape from the severe winter periods.

4. **Suspend:** In certain conditions, if the organisms is unable to migrate, it may avoid the stress by becoming inactive. This is seen commonly in bears going into hibernation during winter. Some snails and fish go into aestivation to avoid summer related problems like heat and desiccation. Some lower animals suspend a certain phase of their life cycle, which is referred to as diapause.

Adaptations

In biology, adaptation i s a dynamic evolutionary process that fits organisms to their environment and enhancing their evolutionary fitness. Adaptations can be a phenotypic or adaptive trait with a functional role in each individual organism that is maintained and has been evolved by natural selection. The adaptive traits may be structural adaptation, behavioural adaptation and physiological adaptation.

a) Structural adaptations

The external and internal structures of animals can help them to adapt better to their environment. Some of the most common examples are mammals growing thicker furto survive freezing climates. Some of the most attractive adaptations in nature occur for reasons of crypsis (e.g. camouflage) and mimicry. Cryptic animals are those which camouflage perfectly with their environment and are almost impossible to detect. Certain reptiles and insects such as chameleons and stick insects show this type of adaptation, which helps in prey capture or to evade from predators. Likewise, horse legs are suitable for fast running and adapted for grasslands and similar terrestrial environments.

b) Behavioural adaptations

Action and behaviour of animals are instinctive or learned. Animals develop certain behavioural traits or adaptations for survival. Fleeing from a predator, hiding during sleep, seeking refuge from climate change or moving to find different food sources are all behavioral adaptations. The two most characteristic forms of behavioral adaptations are migration and courtship. Migration allows the animals to find better resources or evade threat. Courtship is a set of behavioral patterns to find a mate to reproduce. Most nocturnal animals remain underground or inactive during daytime. This is a modification of their feeding and activity pattern or habit or behaviour.

Ethology is the scientific study of animal behavior, under natural conditions.

c) Physiological adaptations

These are adaptations of organisms that help them to live and survive in their environment with unique niches. Example: Lions have sharp canines to hunt and tear meat and a digestive system suitable for digesting raw meat. The two most well-known physiological adaptations are hibernation and aestivation. These are two

different types of inactivity where the metabolic rate slows downso much that the animal can survive without eating or drinking. Aquatic medium and terrestrial habitats have their own respective environmental conditions. Hence organisms have to evolve appropriate adaptations to select suitable habitats and niches.

Adaptations of aquatic animals

1. The pectoral fins and dorsal fins act as stabilizers or balancers and the caudal fin helps in changing the direction as a rudder.
2. Arrangement of body muscles in the form of bundles (myotomes) help in locomotion.
3. Stream lined structure helps in the swift movement of the animals in water.
4. Respiration by gills making use of gases dissolved in water.
5. Presence of air-bladders filled with air for buoyancy.
6. Presence of lateral-line system. They function as rheoreceptors which is helpful in echolocating objects in water.
7. Integuments rich in mucous glands are protected by scales.
8. Maintain water and ionic balance in its body with excretory structures.

Adaptations of terrestrial animals

1. Earthworms, land Planarians secrete a mucus coating to maintain a moist situation for burrowing, coiling, respiration, etc.,
2. Arthropods have an external covering over the respiratory surfaces and well-developed tracheal systems.
3. In vertebrate skin, there are many cellular layers besides the well protected respiratory surfaces that help in preventing loss of water.
4. Some animals obtain their water requirement from food as partial replacement of water lost through excretion.
5. Birds make nests and breed before the rainy season as there is availability of abundant food. But during drought birds rarely reproduce.
6. Camels are able to regulate water effectively for evaporative cooling through the skin and respiratory system and excrete highly concentrated urine, and can also withstand dehydration up to 25% of their body weight.

Populations

Population is defined as any group of organisms of the same species which can interbreed among themselves, and occupy a particular space and function as part of a biotic community. A population has various properties like population density, natality (birth rate), mortality (death rate), age distribution, biotic potential, dispersion and 'r', 'K' selected growth forms. A population possesses genetic characteristics that are directly related to their adaptiveness, reproductive success, and persistence in their habitats over time. Life history of an organism is an

important part of this attribute. The population has a definite structure and function that can be described with reference to time.

Population Attributes

Population density

The density of a population refers to its size in relation to unit of space and time. Population density is the total number of that species within a natural habitat. The size ofe population can be measured in several ways, including abundance (absolute number in population), numerical density (number of individuals per unit area (or) volume) and biomass density (biomass per unit area (or) volume). The population density of a species can also be expressed with reference to the actual area of habitat available to the species (ecological density - Table 11.1). When the size of individuals in the population is relatively uniform then density is expressed in terms of number of individuals (numerical density).

Natality

Populations increase because of natality. Natality is equivalent to birth rate and is an expression of the production of new individuals in the population by birth, hatching, germination (or) fission. The two main aspects of reproduction, namely fertility and fecundity play a significant role in a population. Natality rate may be expressed in crude birth rate number of organisms born per female per unit time.

$$Birth\,rate\,(d) = \frac{number\ of\ birth\ per\ unit\ time}{average\ population}$$

Mortality

Mortality is the population decline factor and is opposite to natality. Mortality can be expressed as a loss of individuals in unit time or death rate. Generally, mortality is expressed as specific mortality, that is, the number of members of an original population dying after the lapse of a given time. The crude death rate of a population can be calculated by the equation.

$$Death\,rate\,(d) = \frac{number\ of\ deaths\ per\ unit\ time}{average\ population}$$

The rate of mortality (death) is determined by density. Mortality is high at high density because of the hazards of overcrowding, increased predation and spread of disease.Mortality rates vary among species and are correlated and influenced by a number of factors such as destruction of nests, eggs or young by storms, wind, floods, predators, accidents and desertion by parents.

Table 11.1 Indices of density

S.No	Indices of Density	Keys
1	Population density	It is usually expressed as the number of individuals per unit area or volume. Eg. 100 trees per acre
2	Crude density	It is the size of population in relation to the numbers per unit of total space. Eg. 1000 fish in a pond.
3	Ecological density	It is the size of a population in relation to the numbers per unit of habitat space. (Available area or volume that can be colonized by a population). Eg. 1000 fish in the volume of water in the pond.
4.	Relative abundance	These are time relative indices which can show the changes in number (increase and decrease) with respect to time. Number of birds of a species spotted per hour in an unit area over a specified time.

Population Dispersion

Populations have a tendency to disperse or spread out in all directions, until some barriers are reached. This is observed by the migration of individuals into (Immigration) or out (Emigration) of the population area.

Migration

Migration is a peculiar and unique kind of mass population movement from one place to another and back. To avoid the severe winter cold, Siberian cranes migrate from Siberia to Vedanthangal in Tamil Nadu and return back in spring. Some fishes are known to migrate from sea to fresh water (anadromous migration, Salmon) and some from fresh water to sea (catadromous migration, Eel).

Emigration

Under natural conditions, emigration usually occurs when there isovercrowding. This is regarded as an adaptive behavior that regulates the population in a particular site and prevents over exploitation of the habitat. Further, it leads to occupation of new areas elsewhere.

Immigration

It leads to a rise in population levels. If the population increases beyond the carrying capacity, it can result in increased mortality among the immigrants or

decreased reproductive capacity of the individuals.Both emigration and immigration are initiated or triggered by weather and other abiotic and biotic factors.

Population Age Distribution:

The proportion of the age groups (pre- reproductive, reproductive and post reproductive) in a population is its age distribution attribute. This determines the reproductive status of the population at the given time and is an indicator of the future population size.Usually a rapidly growing population will have larger proportion of young individuals. A stable population will have an even distribution of various age classes. A declining population tends to have a larger proportion of older individuals (Fig. 11.13).

Growth Models / Curves

Populations show characteristic growth patterns or forms. These patterns can be plotted and termed as J-shaped growth form and S-shaped growth form (Sigmoid form).

J shaped growth form:

When a population increases rapidly in an exponential fashion and then stops abruptly due to environmental resistance or due to sudden appearance of a limiting factor, they are said to exhibit J-shaped growth form. Many insects show explosive increase in number during therainy season followed by their disappearance at the end of the season (Fig. 11.14).

- **Biotic potential:** It is the maximum reproductivecapacity of an organism under optimum environmental conditions.
- **Carrying capacity:** The maximum number of organism that a region can support without environmental degradation is called carrying capacity.
- **Environmental resistance:** Is the sum total of the environmental limiting factors, both biotic and abiotic, which together act to prevent the biotic potential of an organism from being realized.

S-Shaped growth form (sigmoid growth)

Some populations, as in a population of small mammals, increase slowly at first then more rapidly and gradually slow down as environmental resistance increases whereby equilibrium is reached and maintained. Their growth is represented by S shaped growth curve.

Table 11.2 Difference between – selected and K selected species

r selected species	K selected species
Smaller sized organisms	Larger sized organisms
Produce many offspring	Produce few offspring
Mature early	Late maturity with extended parental care
Short life expectancy	Long life expectancy
Each individual reproduces only once or few times in their life time	Can reproduce more than once in lifetime
Only few reach adulthood	Most individuals reach maximum life span
Unstable environment, density independent	Stable environment, density dependent

Population Regulation

The inherent tendency of all animal populations is to increase in number. But it does not increase indefinitely. Once the carrying capacity of the environment is reached, population numbers remain static or fluctuate depending on environmental conditions. This is regulated by many factors which are

1. Density independent – Extrinsic factors
2. Density dependent - Intrinsic factors

Extrinsic factors include availability of space, shelter, weather, food, etc. Intrinsic factors include competition, predation, emigration, immigration and diseases.

Population Interaction

Organisms belonging to different populations interact for food, shelter, mating or for other necessities. Interaction may be intra specific (interaction within the members of same species) or inter specific (among organisms of different species).Intra specific association is observed for all livelihood processes like feeding, territoriality, breeding and protection.Interspecific associations or interactions can be:

Neutral: where different species live together but do not affect each other.

Positive: it is a symbiotic relationship in which no organism in association is harmed and either one or both may be benefitted. It is of two types – Mutualism and Commensalism.

Negative: One or both of the interacting organisms will be affected as in case of competition, predation, and parasitism.

The common types of interspecific inter actions are:

AMENSALISM (--, 0):

This is the ecological interaction in which an individual species harm another without obtaining benefit, large powerful animals harm weak animals. eg., animals destroyed at the feet of elephants.

MUTUALISM (+, +):

It is the type of interaction where both species benefit from the interaction. Mutualism may be facultative when the species involved are capable of existence independent of one another, or obligate, when the relationship is imperative of the existence of one or both species. Examples:

Certain bacteria in the caeca and intestine of herbivores aid in the digestion of cellulose. In return the host provides suitable environment for the growth of the bacteria.The cross pollination of flowers by insects and birds seeking nectar and pollen which is of great importance in agriculture.Small birds cleaning the teeth of crocodiles. Here the birds get food and the teeth of crocodile are cleaned.

Table 11.3 Analysis of two species population interactions

S. No	Types of Interation	Species 1	Species 2	General Nature of Interaction	Examples
1	Amensalism	-	0	The most powerful animal or large organisms inhibits the growth of other lower organisms	Cat and Rat
2	Mutualism	+	+	Interaction favorable to both and obligatory	Between crocodile and bird
3	Commensalism	+	0	Population 1, the commensal benefits, while 2 the host is not affected	Sucker fish on shark
4	Competition	-	-	Direct inhibition of each species by the other	Birds compete with squirrels for nuts and seeds
5	Parasitism	+	-	Population 1, the parasite, generally smaller than 2, the host	Ascaris and tapeworm in human digestive tract.
6	Predation	+	-	Population 1, the predator, generally larger than 2, the prey	Lion predatory on deer

The hermit crab carries along on its shell a Sea anemone (a sedentary coelenterate). The crab is protected from its enemies by the stinging cells of the anemone while the anemone gets its food (Fig. 11.15).

COMMENSALISM (+, 0):

This defines the interaction in which two or more species are mutually associated in activities centering on food and one species at least, derives benefit from the association while the other associates are neither benefited nor harmed. The concept of commensalism has been broadened in recent years, to apply to coactions other than those centering on food such as cover, support, production, and locomotion. Examples:

Barnacles attached to Whales travel thousands of miles collecting and filtering food from the moving water. The whales are not affected by the barnacles.Egrets usually are present near cattle. They catch insects which are disturbed by the cattle. The bird benefits, while the cattles are not affected (Fig. 11.16).

COMPETITION (-- , --):

It refers to the type of interaction in which individuals of a species or members of different species vie for limited availability of food, water, nesting space, cover,mates or other resources. When resources are in more than adequate to meet the demands of the organisms seeking them, competition does not occur, but when inadequate to satisfy the need of the organisms seeking them, the weakest, least adapted, or least aggressive individuals are often forced to face challenges. This phenomenon is known as the competitive exclusion principle of Hardin.

DEGREE OF COMPETITION –

Competition is usually keen between individuals of the same species (intraspecific competition) because they have identical requirements for food, mates, and so on. Interspecific competition occurs where different species require at least some resource materials or conditions in common. The severity of competition depends on the extent of similarity or overlap in the requirements of different individuals and the shortage of the supply in the habitat as birds compete with squirrels for nuts, and seeds; insects and ungulates compete for food in grasslands (Fig. 11.17).

PARASITISM (+, --):

It is a kind of harmful interaction between two species, wherein onecies is the 'parasite' and the other its 'host'. The parasite benefits at the expense of the host. A parasite derives shelter, food and protection from the host. Parasites exhibit adaptations to exploit their hosts. T e parasites may be viral parasites (plant / animal

viruses), microbial parasites (e.g., bacteria / protozoa / fungi), phytoparasites plant parasites) and zooparasites (animal parasites such as Platyhelminthes, nematodes, arthropods). Parasites may inhabit or attach to the surface of the host (Ectoparasites - Head lice, Leech) or live within the body of the host (endoparasites – ascaris, tapeworm). The endoparasites usually live in the alimentary tract, body cavities, various organs or blood or other tissues of the host.

Parasites may be permanent or temporary. Temporary parasites spend only a part of their life cycle as parasites. For example, Glochidium larva of Anadonia (fresh water mussel) attaches itself to the body of fish. Permanent parasites spend their life completely dependent on their host organism. The common examples of permanent parasites are Plasmodium, Entamoeba, Round worms, Pin worms, Tape worms, etc.,

PREDATION (+, --):

It is a form of interaction, where one animal kills another animal for food. Like parasitism, predation is important in community dynamics, but both differ in the point that a predator tends to be larger than its prey, and it catches its prey from without, while a parasite is smaller than its host and consumes it from within.

By their hunting activities predators can be regarded as specialized or generalized. Specialized predators are those adapted to hunt only a few specific species. Lion and deer exhibit predator – prey relationship, where the Lion is the predator and the deer is the prey. This type of interaction helps in the transfer of energy up the trophic levels and is an essential strategy in population regulation (Fig. 11.18).

12th zoology
Unit - 12 Biodiversity and its conservation

Awide variety of living organisms including plants, animals and micro-organisms with whom we share this planet earth makes the world a beautiful place to live in. Living organisms exist almost everywhere from mountain peaks to the ocean depths; from deserts to the rainforests. They vary in their habit and behaviour, shape, size and colour. The remarkable diversity of living organisms forms an inseparable and significant part of our planet, however, the ever increasing human population is posing serious threats to bio-diversity. In this chapter, we shall discuss biodiversity – concepts, levels, magnitude and patterns, importance of biodiversity, biogeographical regions of India, threats to biodiversity, causes of biodiversity loss, extinction, and biodiversity conservation.

Biodiversity

The 1992 UN Earth Summit defined Biodiversity as the variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part. This includes diversity within species, between species and ecosystems of a region. It reflects the number of different organisms and their relative frequencies in an ecological system and constitutes the most important functional component of a natural ecosystem.It helps to maintain ecological processes, create soil, recycle nutrients, influence climate, degrade waste and control diseases. It provides an index of health of an ecosystem.The survival of human race depends on the existence and wellbeing of all life forms (plants and animals) in the biosphere.

Concept of biodiversity

The term biodiversity was introduced by Walter Rosen (1986). Biodiversity is the assemblage of different life forms. Each species is adapted to live in its specific environments.The changes in climatic conditions are reflected in the distribution and pattern of biodiversity on our planet. The number of species per unit area declines as we move from tropics towards the poles. The Tundra and Taiga of northern Canada, Alaska, northern Europe and Russia possess less than 12 species of trees. The temperate forests of the United states have 20-35 species of trees,while the tropical forests of Panama have over 110 species of trees in a relatively small area.

Levels of biodiversity

Edward Wilson popularized the term 'Biodiversity' to describe diversity at all levels of biological organization from populations to biomes. There are three levels of biodiversity - Genetic diversity, Species diversity and Community/Ecosystem diversity (Fig. 12.1).

Genetic diversity refers to the differences in genetic make-up (number and types of genes) between distinct species and to the genetic variation within a single species; also covers genetic variation between distinct populations of the same species. Genetic diversity can be measured using a variety of molecular techniques. India has more than 50,000 genetic variants of Paddy and 1000 variants of Mango. Variation of genes of a species increases with diversity in size and habitat. It results in theformation of different races, varieties and subspecies. Rouwolfavomitaria, a medicinal plant growing in different ranges of the Himalayas shows differences in the potency and concentration of the active ingredient reserpine due to genetic diversity. Genetic diversity helps in developing adaptations to changing environmental conditions.

Species diversity refers to the variety in number and richness of the species in any habitat. The number of species per unit area at a specific time is called species richness, which denotes the measure of species diversity. The Western Ghats have greater amphibian species diversity than the Eastern Ghats. The more the number of species in an area the more is the species richness (Fig. 12.1a). The three indices of diversity are - Alpha, Beta and Gamma diversity.

i. Alpha diversity: It is measured by counting the number of taxa (usually species) within a particular area, community or ecosystem.
ii. Beta diversity: It is species diversity between two adjacent ecosystems and is obtaining by comparing the number of species unique to each of the ecosystem.
iii. Gamma diversity refers to the diversity of the habitats over the total landscape or geographical area.

Community/Ecosystem diversity is the variety of habitats, biotic communities, and ecological processes in the biosphere. It is the diversity at ecosystem level due to diversity of niches, trophic levels and ecological processes like nutrient cycles, food webs, energy flow and several biotic interactions. India with its alpine meadows, rain forests, mangroves, coral reefs, grass lands and deserts has one of the greatest ecosystem diversity on earth.

Magnitude of biodiversity

Biodiversity is often quantified as the number of species in a region at a given time. The current estimate of different species on earth is around 8-9 million. However, we really don't know the exact magnitude of our natural wealth. This is called the 'The Taxonomic impediment'. So far about 1.5 million species of microorganisms, animals and plants have beendescribed. Each year about 10-15 thousand new species are identified and published worldwide, of which 75% are invertebrates. The number of undescribed species is undoubtedly much higher.

India is very rich in terms of biological diversity due to its unique bio-geographical location, diversified climatic conditions and enormous eco-diversity and geo-diversity According to world biogeographic classification, India represents two of the major realms (The Palearctic and Indo-Malayan) and three biomes (Tropical humid forests, Tropical Dry/ Deciduous forests and Warm Deserts/Semi deserts). With only about 2.4% of the world's total land surface, India is known to have over 8 % of the species of animals that the world holds and this percentage accounts for about 92,000 known species.India is the seventh largest country in the world in terms of area. India has a variety of ecosystems, biomes with its varied habitats like, hills, valleys, plateaus, sea shores, mangroves, estuaries, glaciers, grasslands and river basins. It also reflects different kinds of climates, precipitation, temperature distribution, river flow and soil. India is one of the 17 mega biodiversity countries of the world and has ten biogeographic zones with characteristic habitat and biota.

"The world is currently undergoing a very rapid loss of biodiversity comparable with the great mass extinction events that have previously occurred only five or six times in the earth's history."
- World Wildlife Fund

Patterns of biodiversity distribution

The distribution of plants and animals is not uniform around the world. Organisms require different sets of conditions for theiroptimum metabolism and growth. Within this optimal range (habitat) a large number and type of organisms are likely to occur, grow and multiply. The habitat conditions are determined by their latitudes and altitudes.

Latitudinal and altitudinal gradients:

Temperature, precipitation, distance from the equator (latitudinal gradient), altitude from sea level (altitudinal gradient) are some of the factors that determine biodiversity distribution patterns. The most important pattern of biodiversity is latitudinal gradient in diversity. This means that there is an increasing diversity from the poles to equator. Diversity increases as one moves towards the temperate zones and reaches the maximum at the tropics. Thus, tropics harbour more biodiversity than temperate or polar regions, especially between the latitudes of 23.5^0N and 23.5^0S (Tropic of Cancer to the Tropic of Capricorn). Harsh conditions exist in temperate areas during the cold seasons while very harsh conditions prevail for most of the year in polar regions.

Columbia located near the equator (0^0) has nearly 1400 species of birds while New York at 41^0N has 105 species and Greenland at 71^0N has 56 species. India, with much of its land area in the tropical latitudes, is home for more than 1200 species of birds. Thus it is evident that the latitude increases the species diversity.Decrease in species diversity occurs as one ascends a high mountain due to drop in temperature

(temperature decreases @ 6.5^0 C per Km above mean sea level). The reasons for the richness of biodiversity in the Tropics are:

- Warm tropical regions between the tropic of Cancer and Capricorn on either side of equator possess congenial habitats for living organisms.
- Environmental conditions of the tropics are favourable not only for speciationbut also for supporting both variety and number of organisms.

Mean Sea Level (MSL) is an average level of the surface of one or more of Earth's oceans (or seas) from which heights such as elevations may be measured.As we travel by train we notice names of stations on big yellow signboards on which is usually written how much elevated that place is compared to MSL. For example, Erode junction is about 171 meters above MSL.

- The temperatures vary between 25^0C to 35^0C, a range in which most metabolic activities of living organisms occur with ease and efficiency.
- The average rainfall is often more than 200 mm per year.
- Climate, seasons, temperature, humidity, photoperiods are more or less stable and encourage both variety and numbers.
- Rich resource and nutrient availability.

Species - Area relationships

German Naturalist and Geographer Alexander von Humboldt explored the wilderness of south American jungles and found that within a region the species richness increased with increasing area but upto acertain limit. The relationship between species richness and area for a wide variety of taxa (angiosperm plants, birds, bats, freshwater fishes) turned out to be the rectangular hyperbola. On a logarithmic scale, the relationship is a straight line described by the equation.

$$\log S = \log C + Z \log A$$

where

S = Species richness A = Area
Z = Slope of the line (regression coefficient)
C = Y-intercept

Regression coefficient Z generally has a value of 0.1-0.2 regardless of taxonomic group or region. However, in case of the species – area relationship in very large areas like entire continents, the slope of the line appears to be much steeper (Z-value in the range of 0.6-1.2). For example, in case of the fruit eating (frugivorous) birds and mammals in the tropical forests of different continents, the slope is found to be a steeper line of 1.15 (Fig. 12.2)

Importance of biodiversity – Global and India

Biodiversity is the variety of life on earth. That is, it is the number of different species of flora and fauna including microorganisms. These organisms can inhabit different ecosystems with varying conditions like the Rainforests, Coral reefs, Grasslands, Deserts, Tundra and the Polar ice caps. This variety (Biodiversity) is essential for the wellbeing of our planet and sustenance of life as a whole. The importance of biodiversity can be viewed and measured as

a) Ecosystem services b) Biological resources c) Social benefits of biodiversity

The organization and functioning of ecosystems world over is effected and dependent on biodiversity and its richness. The major functional attributes are:

- continuity of nutrient cycles or biogeochemical cycles (N2, C, H2O, P, S cycles)
- soil formation, conditioning or maintenance of soil health (fertility) by soil microbial diversity along with the different trophic members
- increases ecosystem productivity and provide food resources
- act as water traps, filters, water flow regulators and water purifiers (forest cover and vegetation)
- climate stability (forests are essential for rainfall, temperature regulation, CO2 absorption, which in turn regulate the density and type of vegetation)
- forest resource management and sustainable development
- maintaining balance between biotic components
- cleaning up of pollutants – microbes are the biggest degraders of molecules including many anthropogenic ones which are present in effluents, sewage, garbage and agro-chemicals
- ecological stability – the varieties and richness of species contribute to ecological stability and survival of species. Biodiverse regions are reservoirs of biological resources like food resources, gene pool, genetic resource, medicinal resources, bio-prospecting
- to provide unique aesthetic value and hot spots for Ecotourism. Along with forest resources and wildlife it has commercial significance

- an indicator of the health of the ecosystem. Endemism is a crucial indicator of richness.

Do you know?

The interrelationship and interdependence of all living components in a system can be seen from the example of the fruit bats of Guam (South East Asia). The fruit bats are a delicacy here, and hence their population has dwindled which is not surprising. What is surprising is that local fruit production has got affected as it was identified that the bats served as pollinators. Hence there is a need for conservation of diversity as that could avert such situations.

Biogeographical regions of India

As per the international 'biome' type of classification based upon climate, fauna and flora and the soil conditions, India can be divided into ten different biogeographic zones, (Fig. 12.3) namely:

1. **Trans Himalayan Region**: An extension of the Tibetan plateau, high-altitude cold desert in Ladakh (J&K) and LauhalaSpiti (H.P) comprising 5.7% of the country's landmass. The mountains of this region have the richest wild sheep and goat community in the world, renowned for its quality wool and wool products. Otherfauna include Chiru and Black-rocked Crane.

2. **Himalayas**: The entire mountain chain running from north-western to northeastern India, comprising a diverse range of biotic provinces and biomes and covers 7.2% of the country's landmass. The common fauna of the Himalayan ranges, are the wild sheep, mountain goats, shrew, snow leopard and panda, many of which are endangered.

3. **Indian Desert**: The extremely arid area west of the Aravalli hill range, comprising both the salty desert of Gujarat and the sand desert of Rajasthan. It comprises 6.9% of the country's land-mass. Wild ass is endemic to this region. It is also the habitat for the Indian Bustard, camel, foxes and snakes, many of which are endangered.

4. **Semi – Arid Zones**: This zone is between the desert and the Deccan plateau, including the Aravalli hill range covering 15.6% of the country's landmass. Fauna found here are nilghai, blackbuck, four horned antelopes, sambar, chital and spotted deer which are herbivores along with predators like Asiatic lion, tiger, leopard and jackal.

5. **Western Ghats**: Western Ghats, are mountain ranges along the west coast of India, extending over almost 1,500km from Sat Pena in south Gujarat to the southernmost tip of Kerala. The annual rainfall is about 2000 mm. This zone has large populations of Nilgiritahr (State animal of Tamil Nadu), Nilgirilangur, tiger, leopard, and Indian elephant.The grizzled squirrel and lion tailed macaque are endemic to this region.

6. **Deccan Peninsula**: This covers much of the southern and south-central plateau with predominantly deciduousvegetation and 4.3% of the country's landmass. It is known for deciduous forests, thorn forests and pockets of semi ever green forests. Fauna found here are Chital, Sambhar, Nilghai, elephant, sloth bear, black buck and barking deer. It is the catchment area of major Indian rivers like Godavari, Tapti, Narmada and Mahanadi.

7. **Gangetic Plains**: These plains are relatively homogenously defined by the Ganges river system and occupy about 11% of the country's landmass. This region is very fertile and extends up tothe Himalayan foothills. Fauna includes rhinoceros, elephant, buffalo, swamp deer, hog-deer.

8. **North-East India:** The plains and non-Himalayan hill ranges of north eastern India are home to a wide variety of vegetation. With 5.2% of the country's landmass, this region represents the transition zone between the Indian, Indo-Malayan and Indo-Chinese bio-geographical regions and is the meeting point of the Himalayan Mountains andpeninsular India. The North-East is thus the biogeographical 'Gateway' for much of India's fauna and flora and also biodiversity hotspot (Eastern Himalaya), which includes the Indian rhinoceros, leopard and golden langur.

9. **Coastal Region:** Coastal region of India with sandy beaches, mud flats, coral reefs, mangroves constitutes 2.5% of the total geographical area. The coastline from Gujarat to Sundarbans is estimated to be 5423km long. Apart from this a total of 25 islets constitute the Lakshadweep, which are of coral origin and have a typical reef lagoon system, rich in biodiversity. The fauna includes native crabs, turtles and tunas

10. **Andaman and Nicobar Islands**: The Andaman and Nicobar Islands in the Bay of Bengal have highly diverse set of biomes, constituting 0.3% of the total geographical area. They are centers of high endemism and contain some of India's finest evergreen forests and support a wide diversity of corals. Fauna includes Narcondam hornbills of the Andamans and the South Andaman Krait.

Treats to biodiversity

Even though India is one of the 17 identified mega diverse countries of the world, it faces lots of threats to its biodiversity.Apart from natural causes, human activities, both directly and indirectly are today's main reason for habitat loss and biodiversity loss. Fragmentation and degradation due to agricultural practices, extraction (mining, fishing, logging, harvesting) and development (settlements, industrial and associated infrastructures) leads to habitat loss and fragmentation leads to formation of isolated, small and scattered populations and as endangered species.

Some of the other threats include specialized diet, specialized habitat requirement, large size, small population size, limited geographic distribution and high economic or commercial value. Large mammals by virtue of their size require larger areas to obtain the necessities of life - food, cover, mates than do smaller mammals. Individual home range of Lion can be about 100 square Km. Mammals have specialized dietary needs such as carnivores, frugivores and the need to forage

over much larger areas than general dietary herbivores and omnivores. Mammals also have low reproductive output other than small rodents.

Causes of biodiversity loss

The major causes for biodiversity decline are:

- Habitat loss, fragmentation and destruction (affects about 73% of all species)
- Pollution and pollutants (smog, pesticides, herbicides, oil slicks, GHGs)
- Climate change
- Introduction of alien/exotic species
- Over exploitation of resources (poaching, indiscriminate cutting of trees, over fishing, hunting, mining)
- Intensive agriculture and aqua cultural practices
- Hybridization between native and non-native species and loss of native species
- Natural disasters (Tsunami, forest fire, earth quake, volcanoes)
- Industrialization, Urbanization, infrastructure development, Transport – Road and Shipping activity, communication towers, dam construction, unregulatedtourism and monoculture are common area of specific threats
- Co-extinction

Habitat Loss

Development of human society is inevitable. Natural habitats are destroyed for the purpose of settlement, agriculture, mining, industries and construction of highways. As a result species are forced to adapt to the changes in the environment or move to other places. If not, they become victim to predation, starvation, disease and eventually die or results in human animal conflict. Over population, urbanization,industrialization and agriculturaladvancements require additional land, water and raw materials every year. This is made possible only through fragmentation or destruction of natural habitats by filling wetlands, ploughing grasslands, cutting down trees, forest, desilting rivers, constructing transport ways, caving mountains, extracting, ores, changing the course of rivers and filling of seashore.

The most dramatic example of habitat loss comes from the tropical rainforests 14% of the earth's land surface once covered by these tropical forests, is not more than 6% now. The Amazon rainforest, a vast area, harbouring millions of species, also called "Lungs of the planet" is destroyed and being replaced for agriculture and human settlements. 90% of New Zealand's wetlands have been destroyed and cleared for cultivating soya beans and raising grass for beef cattle. Kodaikanal and Nilgiri hills of Tamil Nadu have been destroyed rapidly for human occupancy. Loss of habitat results in annihilation of plants, microorganisms and forcing out animals from their habitats.

Where are the Sparrow?

Common Sparrows are going extinct because of mindless urbanization. They are losing not just their natural habitats but also the essential human touch they need and thrive upon. The population of sparrows is dwindling due to the use of packed food, insecticides in farming and changing lifestyles, and match box-styled architecture resulting in an inadequate availability of food and shelter for the birds. Unlike pigeons that can make nests on ledges, sparrows need cavities to build their nests.

Habitat fragmentation

Habitat fragmentation is the process where a large, continuous area of habitat is both, reduced in area and divided into two or more fragments. Fragmentation of habitats like forest land into crop lands, orchard lands, plantations, urban areas, industrial estates, transport and transit systems has resulted in the destruction of complex interactions amongst species, (food chain and webs) destruction of species in the cleared regions, annihilation of species restricted to these habitats (endemic) and decreased biodiversity in the habitat fragments. Animals requiring large territories such as mammals and birds are severely affected. The elephant corridors and migratory routes are highly vulnerable. The dwindling of many well-known birds (sparrows) and animals can be attributed to this.

Over exploitation:

We depend on nature for our basic needs such as food and shelter. However, when the need becomes greed, it leads to over exploitation of natural resources. Excessive exploitation of a species, reduces the size of its population to such a level that it becomesvulnerable to extinction. Dodo, passenger pigeon and Steller's sea cow have become extinct in the last 200-300 years due to over exploitation by humans. Overfishing due to population pressure leads too many marine fish (populations) declining around the world.

Exotic species invasion:

Exotic species (non-native; alien) are organisms often introduced unintentionally or deliberately for commercial purpose, as biological control agents and other uses. They often become invasive and drive away the local species and is considered as the second major cause for extinction of species. Exotic species have proved harmful to both aquatic and terrestrial ecosystems.Tilapia fish (Jilabikendai) (Oreochromismosambicus) introduced from east coast of South Africa in 1952 for its high productivity into Kerala's inland waters, became invasive, due to which the native species such as Puntiusdubius and Labeokontius face local extinction. Amazon sailfn catfish is responsible for destroying the fish population in the wetlands of Kolkata.

The introduction of the Nile Perch, a predatory fish into Lake Victoria in East Africa led to the extinction of an ecologically unique assemblage of more than 200 nature species of cichlid fish in the lake.African apple snail (Achatinafulica) is the most invasive among all alien fauna in India. This mollusc was first reported in the Andaman and Nicobar Islands. It is now found across the country and threatens the habitat of several native species. Moreover it is becoming a vicious pest in vegetable farms.Exotic earthworms compete for food with native varieties and deplete their population in soil. Papaya Mealy Bug (Paracoccusmarginatus) is native of Mexico and Central America, is believed to have destroyed huge crops of papaya in Assam, West Bengal and TamilNadu.

Global Climate changes

Industrialization is a major contributor to climate change and a major threat to biodiversity. Energy drives our industries, which is provided by burning of fossil fuels. This increases the emission of CO2, a GHG, leading to climate change. Due to large scale deforestation, the emitted CO2 cannot be absorbed fully, and its concentration in the air increases. Climate change increases land and ocean temperature, changes precipitation patterns and raises the sea level. This inturn results in melting of glaciers, water inundation, less predictability of weather patterns, extreme weather conditions, outbreak of squalor diseases, migration of animals and loss of trees in forest. Thus, climate change is an imminent danger to the existing biodiversity (Fig. 12.4).

Shifting or Jhum cultivation (Slash-and-burn agriculture)

In shifting cultivation, plots of natural tree vegetation are burnt away and the cleared patches are farmed for 2-3 seasons, after which their fertility reduces to a point where crop production is no longer profitable. The farmer then abandons this patch and cuts down a new patch of forest trees elsewhere for crop production.This system is practiced in north-eastern regions of India. When vastareas are cleared and burnt, it results in loss of forest cover, pollution and discharge of CO2 which in turn attributes to loss of habitat and climate change which has an impact on the faunal diversity of those regions.

Coextinctions

Coextinction of a species is the loss of a species as a consequence of the extinction of another. (Eg., orchid bees and forest trees by cross pollination). Extinction of one will automatically cause extinction of the other. Another example for co-extinction is the connection between Calvaria tree and the extinct bird of Mauritius Island, the Dodo. The Calvaria tree is dependent on the Dodo bird for completion of its life cycle. The mutualistic association is that the tough horny endocarp of the seeds of Calvaria tree are made permeable by the actions of the large stones in bird's gizzard and digestive juices thereby facilitating easier germination.

The extinction of the Dodo bird led to the imminent danger of the Calvaria tree coextinction.

Pollution

Pollutants and pollution are a major cause for biodiversity loss. Excessive use of fertilisers, pesticides and heavy metals has polluted the land, ground and surface water bodies. There is a tendency of pesticide biomagnification which results in high concentrations at higher trophic levels which has resulted in drastic decline in the population of fish eating birds and falcons. Run off from fertilizer rich fields causes nutrient enrichment of water bodies leading to eutrophication. Mercury, arsenic, cadmium, chromium poisoning has led to depletion of biotic resources in vulnerable ecosystems. Death of vulture population is attributed to the veterinary medicine Diclofenac, which is responsible for the thinning of the egg shells.

Intensive agriculture:

Spread of agriculture is sometimes at the cost of wetlands, grasslands and forests. Intensive agriculture is based on a few high yielding varieties. As a result, there is reduction in the genetic diversity. It also increases vulnerability of the crop plants to sudden attack by pathogens and pests. There are only few varieties of traditional paddy strains today due to use to hybrid varieties in Tamil Nadu.

Forestry: There is a tendency to grow economically important and viable trees like Teak, Sandal, Oak, Sal in forests resulting in loss of other forest trees.

Natural threats: These include spontaneous jungle fires, tree fall, land slide, defoliation by insects or locust attack.

Loss of biodiversity

Species have been evolving and dying out (extinction) ever since the origin of life. However, species are now becoming extinct at a faster rate. This is destabilizing the ecological stability and the distribution of biological diversity on earth. Human activities greatly contribute to the loss of biodiversity. Natural resources such as land, water and organisms are indiscriminately exploited by human beings.According to the Convention of Biological Diversity, direct and indirect human activities have a detrimental effect on biodiversity.

Direct human activities like change in local land use, species introduction or removal, harvesting, pollution and climate change contribute a greater pressure on loss of biodiversity. Indirect human drivers include demographic, economic, technological, cultural and religious factors.Even though new species are being discovered, there is little hope for adding new species through speciation into the biodiversity treasure. Monsoon failure, global warming, depletion in ozone layer,

landslides in hilly states, pollution are a few indirect effects of human activities which results in the loss biodiversity.

IUCN Red List (2004) documents the extinction of 784 species in the 500 years.It is estimated that the current rate of biodiversity loss is 100 to 1000 times higher than the naturally occurring extinction rate and is still expected to grow in the future. This loss of biodiversity has an immense impact on plant animal and human life. The negative effects include dramatic influence on the food web. Even reduction in one species can adversely affect the entire food chain which further leads to an overall reduction in biodiversity. Reduced biodiversity leads to immediate danger for food security by reducing ecosystem services.

Hotspots

Hotspots are areas characterized with high concentration of endemic species experiencing unusual rapid rate of habitat modification loss. Norman Myers defined hot spots as "regions that harbour a great diversity of endemic species and at the same time, have been significantly impacted and altered by human activities."A hotspot is a region that supports at least 1500 endemic vascular plant species (0.5% of the global total) has lost more than 70% of its original vegetation. There are 35 biodiversity hotspots in the world. India is home to four biodiversity hotspots (as per ENVIS). They are

a. Himalaya (the entire Indian Himalayan region)
b. Western Ghats
c. Indo-Burma: includes entire North-eastern India, except Assam and Andaman group ofIslands (and Myanmar, Tailand, Vietnam, Laos, Cambodia and Southern China)
d. Sundalands: includes Nicobar group of Islands (and Indonesia, Malaysia, Singapore, Brunei, Philippines)

Endangered organisms

A species that has been categorized as very likely to become extinct is an Endangered species. Endangered (EN), as categorized by the International Union for Conservation of Nature (IUCN) Red List, is the second most severe conservation status for wild populations in the IUCN's scheme after Critically Endangered (CR).In 1998 there were1102 animal and 1197 plant species in the IUCN Red List. In 2012, the list features 3079 animal and 2655 plant species as endangered (EN) worldwide.

Extinction:

Species is considered extinct when none of its members are alive anywhere in the world. If individuals of a species remain alive only in captivity or other human controlled conditions, the species is said to be extinct in the wild. In both of these situations, the species would be considered globally extinct. A species in considered

to be locally extinct when it is no longer found in an area it once inhabited but is still found elsewhere in the wild.In the 450 million years of life on Earth, there had been 5 mass extinctions, which had eliminated at least 50% of the species of flora and fauna on the globe.The extinction of species is mainly due to drastic environmental changes and population characteristics.There are three types of Extinctions

i. **Natural extinction** is a slow process of replacement of existing species with better adapted species due to changes in environmental conditions, evolutionarychanges, predators and diseases. A small population can get extinct sooner than the large population due to inbreeding depression (less adaptivity and variation).

ii. **Mass extinction**: The earth has experienced quite a few mass extinctions due to environmental catastrophes. A mass extinction occurred about 225 million years ago during the Permian, where 90% of shallow water marine invertebrates disappeared.

iii. **Anthropogenic extinctions:** These are abetted by human activities like hunting, habitat destruction, over exploitation, urbanization and industrialization. Some examples of extinctions are Dodo of Mauritius and Steller's sea cow of Russia. Amphibians seem to be at higher risk of extinction because of habitat destruction.

The most serious aspect of the loss of biodiversity is the extinction of species. The unique information contained in its genetic material (DNA) and the niche it possesses is lost forever.

IUCN

The International Union for Conservation of Nature (IUCN) is an organization working in the field of nature conservation and sustainable use of natural resources. It was established in 1948 and located at Gland VD, Switzerland. It is involved in data gathering and analysis research, field projects and education on conservation, sustainable development and biodiversity. IUCN's mission is to influence, encourage and assist societies throughout the world to conserve nature and to ensure that any use of natural resources is equitable and ecologically sustainable. It influences governments and industries through partnerships by providing information and advice. The organization collects, compiles and publishes the IUCN red list of threatened species and their conservation status in the world. It plays a vital role in the implementation of several international conventions on nature conservation and biodiversity.

Red Data Book

Red Data book or Red list is a catalogue of taxa facing risk of extinction. IUCN – International Union of Conservation of Nature and Natural Resources, which is renamed as WCU – World Conservation Union (Morges Switzerland) maintains the Red Data book. The concept of Red list was mooted in 1963. The purpose of preparation of Red List are:

- To create awareness on the degree of threat to biodiversity
- Identification and documentation of species at high risk of extinction
- Provide global index on declining biodiversity
- Preparing conservation priorities and help in conservation of action
- Information on international agreements on conservation of biological diversity

Red list has eight categories of species Extinct ii) Extinct in wild iii) Critically Endangered iv) Endangered v) Vulnerable vi) Lower risk vii) Data deficiency viii) Not evaluated.

Biodiversity and its conservation

The natural resources of the Earth, including air, water, land, flora and fauna of natural ecosystems must be safeguarded for the benefit of the present and future generations through careful planning and management, as appropriate – Principle of the Stockholm Declaration, 1972.The large-scale loss of biodiversity and its global impact makes conservation the need of the hour. Conservation of biodiversity is protection and scientific management of biodiversity so as to maintain it at its optimum level and derive sustainable benefits for the present as well as future generations. It aims to protect species from extinction and their habitats and ecosystems from degradation.

General strategies in conservation

- identify and protect all threatened species
- identify and conserve in protected areas the wild relatives of all the economically important organisms
- identify and protect critical habitats for feeding, breeding, nursing, resting of each species
- resting, feeding and breeding places of the organisms should be identified and protected
- Air, water and soil should be conserved on priority basis
- Wildlife Protection Act should be implemented

There are two aspects of conservation strategies (Fig. 12.3)

i) In-situ conservation
ii)Ex-situ conservation

In-situ Conservation (Conservation in the natural habitat):

This is the conservation of genetic resources through their protection within a natural or manmade ecosystem in which they occur. It is conservation and protection of the whole ecosystem and its biodiversity at all levels in order to protect the threatened species.Maximum protection of biodiversity hotspots regions with very high levels of species richness. Although all the biodiversity hotspots together cover less than 2 percent of the earth land area, the number of species they harbour is extremely high and protection of these hotspots could reduce the ongoing mass.

Protected Areas:

These are biogeographical areas where biological diversity along with natural and cultural resources is protected, maintained and managed through legal measures. protected areas include national parks, wild life sanctuaries, community reserves and biosphere reserves. World Conservation monitoring centre has recognized 37,000 protected areas world-wide. India has about 771 protected areas covering 162099 km2 comprising of National Parks (104), Wild Life Sanctuaries (544), biosphere reserves (18) and several sacred groves.

National Parks (NP):

It is a natural habitat that is notified by the state government to be constituted as a National Park due to its ecological, faunal, floral, geomorphological, or zoological association of importance. No human activity is permitted inside the national park except the activities permitted by the Chief Wildlife Warden of the state under the conditions given in CHAPTER IV, of the Wildlife Protection Act (WPA) 1972 (Table 12.1).

Project Tiger:

The Government of India launched the 'Project Tiger' in 1973 to protect our national animal. From 9 tiger reserves since its inception, the Project Tiger coverage has increased to 50 at present. Project Tiger is an ongoing Centrally Sponsored Scheme of the Ministry of Environment and Forests, providing central assistance to the states for tiger conservation in designated tiger reserves. Project Tiger was launched in the Jim Corbett National Park, Uttarakhand in1973. The project ensures a viable population of Bengal tigers in their natural habitats, protecting them from extinction and preserving areas of biological importance as a natural heritage.

The National Tiger Conservation Authority (NTCA) is a statutory body of the Ministry, created under the Wildlife (Protection) Act, 1972. India holds over half the world's tiger population. According to the latest tiger census report released on 20th January 2015 by NTCA, the current tiger population is estimated at 2,212. There are 50 tiger reserves in the

country.

Table 12.1 National Parks in Tamil Nadu

National Parks in Tamil Nadu	Year of establishment	District(s)
Guindy NP	1976	Chennai
Gulf of Mannar Marine NP	1980	Ramanathapuram and Tuticorin
Indira Gandhi (Annamalai) NP	1989	Coimbatore
Mudumalai NP	1990	Nilgris
Mukurthi NP	1990	Nilgris

There are 104 existing national parks in India covering an area of 40,501 km2, which is 1.23% of the geographical area of the country (National Wildlife Database, Aug. 2018). National Park is an area which is strictly reserved for the betterment of wildlifeand biodiversity and where activities like development, forestry, poaching, hunting, grazing and cultivation are not permitted. They are large areas of scenic and national beauty maintained for scientific educational and recreational use. They are not used for commercial extraction of resources. Kaziranga National park is a protected area for the one Horned Rhinoceros in Assam.

Wild Life Sanctuaries (WLS):

Any area other than the area comprised with any reserve forest or the territorial waters can be notified by the State Government to constitute as a sanctuary if such area is of adequate ecological, faunal, floral, geomorphological, natural or zoological significance. This is for the purpose of protecting, endangered factual species. Some restricted human activities are allowed inside the Sanctuary area details of which are given in CHAPTER I V, of the Wildlife Protection Act (WPA) 1972. Ecotourism is permitted, as long as animal life is undisturbed.

There are 544 existing wildlife sanctuaries in India covering an area of 118,918 km2, which is 3.62 % of the geographical area of the country (National Wildlife Database, 2017).Sanctuaries are tracts of land where wild animals and fauna can take refuge without being hunted or poached. Other activities like collection of forest products, regulated harvesting of timber, private ownership of land are permitted. Periyar wild life sanctuary in Kerala is famous for the Indian Tiger and Asiatic Elephant (Table 12.2).

Table 12.2 Wild life sanctuaries in Tamil Nadu

Prominent WLS in Tamil Nadu	Year of establishment	Districts
Vedanthangal Lake Birds WLS	1936	Chengalpet
Mudumalai WLS	1942	Nilgiris

Point Calimere WLS	1967	Nagapattinam
Indira Gandhi (Annamalai) WLS	1976	Coimbatore
Mundanthurai WLS	1977	Tirunelveli

THE MADRAS CROCODILE BANK TRUST

The Madras Crocodile Bank Trust and Centre for Herpetology was the brain child of the legendary Romulus Whitaker and a handful of like-minded conservation visionaries, who began work on the facility in 1976. It aimed to save India's dwindling crocodilian population. The mission is to promote the conservation of reptiles and amphibians and their habitats through education, scientific research and capture breeding. The crocodile bank remains a world leader in the field of frontline conservation and the preservation of natural landscapes. The Crocodile Bank currently consists of a large reptile park near Chennai and several field projects located throughout the subcontinent reaching as far as the Nicobar Islands. About half a million people visit the bank every year, making it one of the most popular tourist attractions along the East Coast Road.

Arignar Anna Zoological Park, Vandalur

Arignar Anna Zoological Park is spread over an area of 602 hectares. of Reserve Forest at Vandalur, Chennai. It is one of the largest zoo in South East Asia in terms of area. The Zoological Park exhibits different classes of animals - it has around 2500 wild animals of nearly 180 species which includes Mammals, Birds and Reptiles. 34 years since its establishment, the Zoological Park has emerged as a successful ex-situ conservation centre and a captive breeding centre for many endangered species like Royal Bengal Tiger, Lion Tailed Macaque, NilgiriLangur, Gray Wolf, etc.,

The Zoo has many attractive features like Butterfly Park, Children's Park, Walk Through Aviary, Lion & Deer Safari, Forest Museum, Interpretation centre, etc., which attractsof installing CCTV Cameras for both visitors and animal management under the name of Zoo e-Eye. 24 x 7 Animal Live Streaming was introduced for the benefit of the visitors for the first time in the world. Vandalur Zoo Mobile Application was introduced to provide services to the visitors like facility to book tickets, Zoo navigation, Animal information in text and audio format. Digital payments at ticket counters are also available.

The Zoo school has been involved in education and outreach programmes. One such successful programme is 'Zoo Ambassador' which is been conducted for school children. In the year 2018, more than 400 students were trained and titled as Zoo Ambassadors. The Zoo also has a Rescue Centre which accommodates rescued wild animals and treats them to come out of stress.

Source: Director, Arignar Anna Zoological Park, Vandalur, Chennai

Biosphere Reserve (BR):

Biosphere Reserve (BR) is an international designation by UNESCO for representative parts of natural and cultural landscapes extending over large area of terrestrial or coastal/ marine ecosystems or a combination thereof. BRs are designated to deal with the conservation of biodiversity, economic and social development and maintenance of associated cultural values. Biosphere Reserves are thus special environments for both people and nature and are living examples of how human beings and nature can co-exist while respecting each other's needs. The Biosphere Reserve Programme is guided by UNESCO's Man and Biosphere (MAB) programme, as India is a signatory to the landscape approach supported by MAB programme. The scheme called Biosphere Reserve was implemented by the Government of India in 1986. There are 18 Biosphere Reserves in the country. Agasthyamalai (Karnataka - Tamil Nadu -Kerala), Nilgiri (Tamil Nadu - Kerala), Gulf of Mannar (Tamil Nadu) are the BRs notifed in Tamil Nadu.

Sacred Groves

A sacred grove or sacred woods are any grove of trees that are of special religious importance to a particular culture. Sacred groves feature in various cultures throughout the world.

Ex-Situ Conservation

It is conservation of selected rare plants/ animals in places outside their natural homes. It includes offsite collections and gene banks.

Offsite Collections:

They are live collections of wild and domesticated species in Botanical gardens, Zoological parks, Wildlife safari parks, Arborata (gardens with trees and shrubs). The organisms are well maintained for captive breeding programmes. As a result, many animals which have become extinct in the world continue to be maintained in Zoological Parks. As the number increases in captive breeding, the individuals are selectively released in the wild. In this way the Indian crocodile and Gangetic dolphin have been saved from extinction.

Gene Banks:

Gene banks are a type of biorepository which preserve genetic materials. Seeds of different genetic strains of commercially important plants can be stored in long periods in seed banks, gametes of threatened species can be preserved in viable and fertile condition for long periods using cryopreservation techniques.However, it is not economically feasible to conserve all biological wealth and all the ecosystems. The number of species required to be saved from extinction far exceeds the conservation efforts.

Different between Insitu and Exsitu Conservation

Insitu Conservation	Existu Conservation
It is the on-site conservation or the conservation of genetic resources in natural populations of plant or animal species.	This is a conservation strategy which involves placing of threatened animals and plants in special care locations for their protection.
It is the process of protecting an endangered plant or animal species in its natural habitat, either by protecting or restoring the habitat itself, or by defending the species from predators.	It helps in recovering populations or preventing their extinction under simulated conditions that closely resemble their natural habitats.
National Parks, Biosphere Reserve, Wild Life Sanctuaries form insitu conservation strategies	Zoological parks and Botanical gardens are common exsitu conservation programs.

Role of WWF and CITES

World Wild Fund for Nature (WWF) is an international non-governmental charitable trust founded in 1961, with headquarters at Gland, Vaud, Switzerland. It aims at wildness preservation and the reduction of human impact on the environment. It was formerly named the World Wildlife Fund. The living planet report is being published every two years by WWF since 1998.The vision of WWF is to conserve nature and reduce the most pressing threats to the diversity of life on Earth by conserving the world's most ecologically important regions, protect and restore species and their habitats, strengthen local communities' ability to conserve the natural resources they depend upon and to ensure that the value of nature is reflected in decision made by individuals, communities, governments and businesses.

CITES:

The Convention on International Trade in Endangered Species (CITES) of wild faunaand flora, also known as the Washington Convention, is a multilateral treaty to protect endangered plants and animals. It was drafted from a resolution adopted from a meeting of members of the IUCN in 1963 and opened for signature in 1973. It came into force during July 1975.It aims to ensure that international trade in specimens of wild animals and plants should not be a threat to the survival of the species in the wild. It accords varying degrees of protection to more than 35,0000 species of animals and plants.

ZOOLOGICAL SURVEY OF INDIA

The Zoological Survey of India (ZSI) was established in 1916 to promote

survey, exploration and research leading to the advancement in our knowledge of various aspects of biodiversity of our country.

The objectives of ZSI are:

- Exploration, Survey, Inventorying and Monitoring of faunal diversity in various states, ecosystems and protected areas of India.
- Periodic review of the status of threatened and endemic species.
- Preparation of Red Data Book and Fauna of India.
- Biological studies on selected important species.
- Maintenance and Development of National Zoological Collections.

Restoration of Degraded Habitat

Biodiversity conservation through eco development - an Indian case study

The Forestry Research Education and Extension Project FREEP (A World Bank Initiative) in India is employing a strategy called 'eco development' which enlists local commodities in the preservation of biodiversity. The strategy involves developing alternate resources and sources of income for those who depend on the protected natural habitat (forest) for their livelihood.

FREEP is conducting pilot eco-development programmes in the Kalakad-Mundanthurai Tiger Reserve (KMTR) in Tamil Nadu. The reserve contains a unique and varied array of flora ranging from thorn and dry teak to tropical evergreen, and supports a rich variety of birds and mammals, including tigers, leopards and elephants.Te last tiger refuge in Tamil Nadu, the KMTR is one of 50 sites covered under the Indian Government's Project Tiger, a programme receiving international assistance to enhance tiger habitat.

Over 100 villages are now participating in the KMTR project. Communities and individual farmers have planted fuelwood and fodder plantations. Some villagers have installed cow dung-based gas plants for home fuel needs and are using fuel-saving pressure cookers and more efficient wood-burning stoves (smokeless chulas). Loans for a wide array of alternative income-generating activities such as dairy and poultry farming, tailoring, coconut leaf weaving, and setting up tea and dry goods shops are made available. Thus, the eco-development programme at the KMTR is rapidly coming to be seen as a model for conserving biodiversity through local participation.

CONVENTION ON BIOLOGICAL DIVERSITY (CBD)

The United Nations convention on Biological Diversity, known as CBD in short, was signed by India and 172 other nations on December 29, 1993. The CBD was an attempt to establish an international program for conserving and using the world's biological resources. This historical treaty recognizes the "sovereign right of

nation over their genetic resources" and considers "appropriate access to genetic resources." The treaty also takes into account the "fair and equitable sharing" of benefits arising from the use of genetic resources.

Biodiversity Act (BDA)

The Convention on Biological Diversity (CBD) is a United Nations initiative to protect Biodiversity and encourage the sustainable use of natural resources. The convention was held in 1992 at the 'Earth Summit' in Brazil. India is a signatory of the CBD. The Biological Diversity Act, 2002 is an Act of the Parliament of India for preservation of biological diversity in India, and provides mechanism for equitable sharing of benefits arising out of the use of traditional biological resources and knowledge. The Act was enacted to meet the obligations under Convention on Biological Diversity (CBD), to which India is a party.

The National Biodiversity Authority (NBA) was established by the Central Government in 2003 to implement India's Biological Diversity Act (2002). The NBA is a Statutory Body and it performs facilitative, regulatory and advisory functions for the Government of India on issues of conservation, sustainable use of biological resources and fair and equitable sharing of benefits arising out of the use of biological resources. The Headquarters of the NBA is situated in Chennai.

Unit – 13 Environmental Issues

Aclean environment is very necessary to live a peaceful and healthy life. But our environment is getting dirty day by day because of our negligence. Earth is currently facing a lot of environmental concerns like air pollution, water pollution, and noise pollution, global warming, acid rain, biomagnification, eutrophication, deforestation, waste disposal, ozone layer depletion and climate change. Over the last few decades, the exploitation of our planet and degradation of our environment have gone up at an alarming rate. As our actions have not been in favour of protecting this planet, we have seen natural disasters striking us more often in the form of flash foods, tsunami and cyclones."Every individual should be environmentally aware, regardless of whether they work with environmental issues or not."

Pollution

Pollution is any undesirable change in the physical, chemical and biological characteristics of the environment due to natural causes and human activities. The agents which cause pollution are called pollutants. Pollution isclassified according to the types of environment that is affected. They are mainly air, water and soil pollution.

Classification of Pollutants

In terms of eco-system, pollutants can be classified into two basic groups – Non-degradable and degradable. Based on the time taken to breakdown into their ingredients, degradable pollutants are classified as rapidly degradable (non-persistent) and slowly degradable (persistent).

a) Rapidly degradable or non-persistent pollutants: These can be broken down by natural processes. Domestic sewage and vegetable waste are examples of such pollutants.

b) Slowly degradable or persistent pollutants: These are pollutants that remain in the environment for many years in an unchanged condition and take decades or longer to degrade, as in the case of DDT.

c) Non-degradable pollutants: These cannot be degraded by natural processes. Once they are released into the environment, they are difficult to be eliminated andcontinue to accumulate (biomagnifcation). Toxic elements like lead, mercury, cadmium, chromium and nickel are such common pollutants.

Air Pollution

Earth is surrounded by a gaseous envelope which is called atmosphere. The gaseous blanket of the atmosphere acts as a thermal insulator and regulates the temperature of the earth by selectively absorbing The UV rays of solar radiation. The adverse effects of pollution include depletion of Ozone by Chlorofluorocarbons or CFCs, used as refrigerants and global warming by elevated CO2 (industries, deforestation, and partialcombustion).

The alterations or changes in the composition of the earth's atmosphere by natural or human activities (anthropogenic factors) are referred as Air Pollution. Pollutants include the abundant presence of solid, liquid or gaseous substances produced by human or natural activity. The nature and concentration of a pollutant determines the severity of detrimental effectson organisms and human health. Along with atmospheric factors (humidity, precipitation, wind, air currents, altitude) prevailing at a place and time, its effects can be far reaching and catastrophic.

Air pollutants can be

- discharge of dusts or particulate matter (PM: 2.5 ,10)
- discharge of gases (SO2, NO2, CO, CO2)

Carbon monoxide (CO) is produced mainlydue to incomplete combustion of fossil fuels. Automobiles are major causes of CO pollution in large cities and towns Automobile exhausts, fumes from factories, emission from power plants, forest fires and burning of fire-wood contribute to CO pollution.With rapid urbanization, major amount of carbon dioxide and sulphur dioxide (SO2) is released in the atmosphere. From automobiles, aeroplanes, power plants and other human activities that involving the burning of fossil fuels (coal, oil etc.,) CO2 is the main pollutant that is leading to global warming.

Nitrogen oxides are also major air pollutants. Fossil fuel combustion and automobiles exhausts are the source of nitrogen oxides. Sulphur dioxide and nitrogen oxides are the major causes of acid rain.Particulate matters are tiny particles of solid matter suspended in a gas or liquid. Combustion of fossil fuels, fly ash produced in thermal power plants, forest fires, asbestos mining units, cement factories are the main sources of particulate matter pollution.

Sources

The main sources of air pollution are:

- Transport sources– cars, buses, airplanes, trucks, trains
- Stationary sources – power plants, incinerators, oil refineries, industrial facilities, and factories
- Area sources – agricultural - wood / stubble burning, fireplaces
- Natural sources – wind-blown dust, wildfires, volcanoes

Effects of Air Pollution

- Affects all organisms as they depend on the atmosphere for respiration.
- Causes irritation in the throat, nose, lungs and eyes. It causes breathing problems and aggravates existing health conditions such as emphysema and asthma.
- Contaminated air reduces the body's defense mechanism and decreases the body's capacity to fight other infections in the respiratory system.
- Frequent exposure to polluted air increases the risk of cardiovascular diseases. Breathing air that is filled with fine particulate matter can induce hardening of the arteries, triggering cardiac arrhythmia or even a heart attack.
- People who exercise outdoors can sometimes be susceptible to adverse effects of air pollution because it involves deeper and faster breathing. Hence it is advisable to walk or jog in the mornings in places with ample tree cover.
- Gas leaks can be lethal or affect the quality of air in the affected area.
- CO in the atmosphere interferes with O2 transport since haemoglopin has greater affinity for carbon monoxide. At low concentration it causes headache and blurred vision. In higher concentration, it can lead to coma and death.

Do you know?

Sameer, an App provideshourly updates on theNational Air Quality Index(AQI) published by CPCB.

Other notable effects of Air Pollution

1. **Smog** is a type of air pollution caused by tiny particles in the air. The word comes from a mixture of the words smoke and fog.Today, smog generally refers to photochemical smog, which is created when sunlight reacts with nitrogen oxides and volatile organic compounds found in fossil fuel emissions from automobiles, factories, and power plants. These reactions create ground-level ozone and particulate matter, reducing visibility. Smog can make breathing more difficult, especially for people with asthma.Smog also affects plants and animals. It damages crops as well as causes health problems in pets, farm animals and human beings. Smog has also been known to cause corrosive damage to buildings and vehicles.

2. **Peroxyacetyl nitrate** (PAN) is a secondary pollutant present in photochemical smog. It is thermally unstable and decomposes into peroxyethanol radicals and nitrogen dioxide gas causing eye irritation.

3. **Global warming:** Increase in the concentrations of greenhouse gases such as CO2, methane, nitrous oxide, CFCs, and ozone causes greenhouse effect,

warming of the earth, resulting in sea level rise, submerging of islands and sea shores of various parts of the world.

4. **Ozone depletion:** Tinning of the stratospheric ozone layer is known as ozone depletion. Such depletion causes the 'ozone hole', resulting in poor screening of the harmful UV rays and increase in incidences of skin cancer. Some of the common agents that deplete ozone are CFCs.

5. **Acid rain:** Acid rain is a form of precipitation that contains acidic components, such as sulfuric acid or nitric acid. It damages trees, crops and harms marine animals (coral reefs) and induces corrosion.

Control of Air Pollution

Certain measures help to remove pollutants, reduce their presence or prevent their entry into the atmosphere.

- Trees are the best remedy for urban particulate and gaseous pollution
- Forests act as carbon sinks and lungs of the planet
- Catalytic converters in vehicles help to reduce polluting gases drastically
- Diesel exhaust filters in automobiles cuts particulates
- Electrostatic precipitators reduce release of industrial pollutants.
- Cost effective air pollution treatment systems like indoor plants and high performance biofilters can improve indoor air quality.

The TajMahal, a UNESCO world heritage site, is facing deterioration and damage by industrial gases due to several industrial units around Agra. The white marble has decolorized to yellow.

Legal Protection

- The Air (Prevention and Control of Pollution) Act was enacted in 1981 and amended in 1987 for the prevention, control and abatement of Air pollution in India.
- Traffic Emissions Standards: The Government has decided to enforce Bharat Stage VI norms from 2020.
- The Green Bench and the National Green Tribunal (NGT) give judicial safeguard to environmental protection.

Steps taken by the Central and the State governments in India:

- Road traffic rationing, encourage public transport, carpooling.
- Increase green cover alongside roads (planting avenue trees).
- Promoting Swachh Bharat Abhiyan
- Enactment and Enforcement of stricter environmental laws

- Maintenance of air standards by proper enforcement and monitoring

Average human consumption of Oxygen per day = 550 L Cost of 2.75 L Oxygen cylinder = ₹ 6500 Cost of 550 L of oxygen from tree = ₹ 13,00,000

Oxygen production by one healthy tree per year = 1,00,375 L Cost of 2.75 L oxygen cylinder = ₹ 6500 Cost of 1,00,375 L of oxygen from one tree /year = ₹ 23,72,50,000

Reducing carbon emissions

- Encourage use of renewable energy
- Limiting the sale of firecrackers and developing eco-friendly crackers
- Make Environmental Impact Assessment mandatory

Air Quality Index (AQI) is a number used by government agencies to communicate to the public how polluted the air is at a given time.

Air Quality Index		
AQI	**Air Pollution Level**	**Colour**
0 – 50	Good	Green
51 - 100	Moderate	Light Green
101 – 150	Unhealthy for Sensitive Groups	Yellow
151 – 200	Un healthy	Orange
201 – 300	Very Unhealthy	Red
301 +	Hazardous	Maroon

Water Pollution

Quality of Water

Water is essential for life and for the health of the environment. As a valuable natural resource, it comprises marine, estuarine, freshwater (river and lakes) and groundwater environments that stretch across coastal and inland areas. Water has two dimensions that are closely linked: quantity and quality. Water quality is commonly defined by its physical, chemical, biological and aesthetic (appearance and smell) characteristics. A healthy environment is one in which the water quality supports a rich and varied community of organisms and protects public health.

Water Pollution

Water pollution occurs when there is a change in the chemical, physical or biological quality of water that has harmful effect(s) on living organisms that consume it or live in it.Water pollution adversely affects water bodies due to the

large amounts of natural or man-made materials let into it. When it becomes unfit for its intended use, water is considered polluted.

Sources of Water Pollution

Even though water bodies or sources can be polluted by natural causes, water pollution is usually caused by human activities. There are three main types of sources: point sources, non-point sources, leaks and spills.

- ✓ **Point sources:** Discharge of pollutants at specific locations through pipelines or sewers into the water body. Factory effluents, sewage, underground mines, oil wells, oil tankers and agriculture are common point sources (Fig. 13.2 a).

- ✓ **Non-point sources:** Sources that cannot be traced to a single site of discharge like acid rain, dumping of the plastics in water bodies, agriculture chemical run off are common examples.

- ✓ **Leaks and Spills:** This occurs mostly due to ship collision, off shore oil rigs, oil leakages and discharges into sea (Fig. 13.2 c).

Sources of water pollution can also be classified in three ways. They are municipal wastes, industrial wastes, and agricultural wastes.

	Source of Water pollution	
Municipal wastes	Industrial wastes	Agricultural wastes

1. Municipal waste water is from homes and commercial establishments.
2. Industrial discharge (effluents) may contain varieties of compounds such as heavy metals (cadmium, chromium, lead), and organic / inorganic chemicalscontaining waste water, sometimes in toxic concentrations. These discharges can affect temperatures of the water bodies as well as dissolved oxygen level.
3. Agricultural wastes include fertilizer and pesticide runoff from agricultural fields, food processing waste, and tree and saw dust from logging operations and bacteria from sewage or livestock operations.
4. Water pollutants reach water bodies like rivers, streams and the marine system by precipitation, run-off and the groundwater by seepage or percolation.

Effect of Water pollution on Ecosystems

1. Destruction of ecosystems: Ecosystems, especially aquatic systems, can be severely affected or destroyed by water pollution.Water pollutants affect existing niches and habitats and the survival of organisms. Soil fertility is affected and the system becomes uninhabitable.

2. Disruption of food-chains: Water pollution disrupts the natural food chains as well as food webs. Pollutants such as lead and cadmium are taken up by primary consumers where they can be lethal or get stored. Later, when these animals are consumed by secondary consumers, the food chain can get disrupted at any trophic level or result in enhanced concentration of these pollutants (bio-magnification). Hot water from industries when released into the water bodies affects aquatic density and diversity.

Effect of Water pollution on Organisms

1. Water pollution can be lethal to aquatic organisms and others that depend on these water bodies.Accidental oil spills from tanker ships can cause substantial environmental damage. Oil spreads on the water surface, prevents the entry of light and oxygen into the water. Tis increases BOD and COD, resulting in mass death of organisms and degradation of water quality. It also clogs fish gills and the feathers of aquatic birds.

On January 28, 2017, two cargo ships collided off the Ennore coast in Chennai causing oil to spill into the sea. Due to wave action and the southern current, the spill spread over to 34 km down south affecting the coast. Beach sand also got spoiled by the oil sludge. It took more than a thousand volunteers to clean the oil sludge.

2. Humans and other organisms can get affected by diseases such as hepatitis and typhoid by consuming contaminated water and food. Excess of fluoride in drinking water causes fluorosis. In many poor nations, outbreak of water borne diseases and epidemics are a result of contaminated water and poor or absence of water treatment processes.

3. Water pollution can cause eutrophication due to nutrient enrichment. This causes algal blooms which affect the quality of water bodies (Fig. 13.3). Red tides, if occur, can be lethal to aquatic organisms.

Control Measures

1. Right to clean water is a fundamental right under the Indian Constitution.
2. Water (Prevention and Control of Pollution) Act, 1974, sections 17 to 40 prohibit the pollution of a stream or well by disposal of polluting matter.
3. The Central/State Pollution Control Boards have the power to advise the central/state government on various matters concerned with the prevention and control of pollution of water.
4. The Ministry of Environment, Forest and Climate Change (MoEFCC) is the nodal agency of the Central Government for the planning, promotion, co-

ordination and for overseeing the implementation of India's environmental and forestry policies and programmes.

Prevention

- Regulate or control of pollutant(s) discharge at the point of generation.
- Wastewater can be pretreated by scientific methods before discharge to municipal treatment sources.
- Setting up of Sewage Treatment Plants (STP) and Effluent Treatment Plants (ETP).
- Regulate or restrict the use of synthetic fertilisers and pesticides.
- Public awareness and peoples' involvement is essential.

Assessment by CPCB

The number of polluted stretches in India's rivers has increased to 351 from 302 (in 2006), and the number of critically polluted stretches - where water quality indicators are the poorest - has gone up to 45 from 35 (Source: The Hindu, September, 2018).

Case study

NamamiGange (National Mission for Clean Ganga) Programme is an Integrated Conservation Mission approved as the 'Flagship Programme' of the Union Government in June 2014 with a budget outlay of 20,000 crores to accomplish the twin objectives of effective abatement of pollution, conservation and rejuvenation of River Ganga.

Noise Pollution

Sound that is unwanted and undesirable or can disrupts one's quality of life is called as Noise. When there is lot of 'noise' in the environment, it is termed as Noise Pollution. The intensity of noise is measured in decibels (dB).

Sources of Noise Pollution

Vehicle engines, air horns, audio video systems, trains, low flying aircrafts, factory machines, sirens, motors, drillers and crushers, compressor machines, crackers, explosives, modern supersonic transports are the common sources of noise pollution.The threshold of pain is about 120 db. World Health Organization has proposed that noise must be recognized as a major threat to human well-being. This is applicable for all living organisms.

Effect of Noise Pollution

According to the USEPA (United States Environmental Protection Agency) there are direct links between noise and health. Heart disease, high blood pressure, stress related illness, sleep disruption, hearing loss (deafness), and productivity loss are the problems related to noise pollution.

- Increased stress and tension, nervousness, irritability, anxiety, depression and panic attacks.
- Peptic ulcer, severe head ache, memory loss.
- Marine animals are affected by noise pollution from offshore activities and port activities.
- Fire crackers frighten animals. Birds are often affected by increased air traffic.

Control

- Planting trees in and around noise sources is an effective solution for noise pollution as plants are known to absorb noise and bring down sound levels.
- Regular servicing and tuning of automobile engines can effectively reduce noise pollution by vehicles and machinery.
- Workers should be provided with ear plugs and earmuffs at work sites that generate high noise levels.
- Lubrication of machinery and regular servicing minimizes noise levels.
- Regulations should be imposed to restrict the usage of loudspeakers in crowded areas and public places.

Legal Protection

- Article 48-A and Article 51-A of the Constitution of India, Noise Pollution (Regulation and Control) Rules 2000, and Tamil Nadu State Environment Policy 2017 are some of the legal relief from noise pollution.
- According to Noise Pollution (Regulation and Control) Rules, 2000, the permissible limit of noise in areas categorized as commercial is 65 decibels (dB) during day and 55 dB during night.

Agrochemicals

- Chemicals which are used in agriculture for growth of plants and pest control are called agrochemicals or agrichemicals.
- Overuse of agrochemicals have been observed to generate residues that cause nutrient imbalance, and
- May kill beneficial bacteria and soil organisms.
- Can cause eutrophication in water bodies.
- Affect aquatic animals and their productivity.
- Pesticide containing water, even in trace quantities is unfit for human consumption.
- Particles (aerosols) and residues of these chemicals cause air pollution.

- Inhalation of contaminated air can cause respiratory problems.
- Consumption can lead to poisoning, side effects and after effects.
- Chemicals can cause skin rashes and irritation of eyes.
- Many of these chemicals are reported to be carcinogenic.

- They can trigger hormonal disorders and neurotoxicity.
- Beneficial insects and animals can be affected.

1. **Mosquito Repellents:** DEET (n-n-diethylnetatoluamide)and allethrin used in mosquito coils may cause itching, burning, tingling sensation or numbness.

2. **Colony collapse syndrome** in Honey bees due to pesticides/herbicides can lead to destruction of hives and lower agricultural productivity.**!!Remember bees are Nature's best pollinators!!**

Bio-magnification

Food chains are components of all ecosystems. Producers and consumers form trophic levels in a chain through which energy flow is carried out by the process of eating and being eaten. Usage, storage and transformation of food and biomolecules by metabolism are a normal process. Degradation or breakdown is an essential part of any food chain and hence all naturally occurring substances are degradable.

Bio- magnification of DDT

When non-degradable substances enter the food chain, they do not get metabolized or broken down or expelled and instead get transferred up the tropic levels of the food chain. During this process, they show an increase in concentration which is referred to as biomagnifcation. This results in increased toxicity and may even be lethal. Tis phenomenon is well established for mercury and DDT. Figure 13.4 schematically shows biomagnifcation of DDT in an aquatic food chain where the concentration of DDT is enhanced at successive trophic levels.

Eutrophication

When run-of from land containing nutrients reaches water bodies like lakes, it results in dense growth of plant life. Tis phenomenon is called Eutrophication. Natural aging of lakes also leads to nutrient enrichment of its water. In a lake, the water is cold and clear (oligotrophic stage), supporting little life. With time, streams draining into the lake introduce nutrients such as nitrates and phosphates, which

encourage the growth of aquatic organisms. Aquatic plants and animal life grow rapidly, and organic remains begin to be deposited on the lake bottom (mesotrophic stage) (Fig. 13.5).

Pollutants from anthropogenic activities like effluents from the industries and homes can radically accelerate the aging process. Tis phenomenon is known as Cultural or Accelerated Eutrophication.Nutrients stimulate the growth of algae, water hyacinth and can cause clogging of canals, rivers and lakes as well as, displacing native plants. It causes unsightly foam and unpleasant odours, and deprives the water of dissolved oxygen.

Integrated Wastewater Management

Wastewater Treatment

Wastewater or sewage originates from domestic waste waters, industrial wastes andanimal wastes. Realizing the importance of clean potable water, the Government passed the Water (Prevention and Control of Pollution) Act in 1974, which made it mandatory to treat wastewater in treatment plants. Te treatment can be carried out by three ways:

1. Physical methods
2. Chemical methods
3. Biological methods

1. Physical methods of wastewater treatment

Wastewaters containing insolublesubstances or colloids are treated through processes such as flotation, sedimentation, filtration and centrifugal separation.

2. Chemical methods of Wastewater treatment

Chemical methods of wastewater treatment include:

- Generation of insoluble solids.
- Produce an insoluble gas.
- Produce biologically degradable substances from a non-biodegradable substance.
- Oxidize or reduce to produce a non-objectionable substance.

3. Biological methods of Wastewater treatment

1. Bioremediation of wastewater includes the aerobic treatment (oxidation ponds, aeration lagoons) and anaerobic treatment (anaerobic bioreactors, anaerobic lagoons).

2. Phytoremediation of wastewater includes constructed wetlands, Root Zone Wastewater Treatment (RZWT), and Decentralized Waste Water Treatment System (DEWATS) (Fig. 13.6 a).

Case Study: Auroville, located in South India near Puducherry has been experimenting with natural wastewater recycling systems (Fig:13.6a). Such treatment plants have now also been implemented in Aravind Eye Hospital, Puducherry (Fig.13.6 b) and the Chennai Mathematical Institute, Siruseri IT Park, Chennai.

Organic Farming and Its Implementation

It is a method of farming system which primarily aims at cultivating the land and raising crops in such a way, so as to keep the soil alive and in good health by use of organic wastes (crop, animal and farm wastes, aquatic wastes) and other biological materials along with beneficial microbes (biofertilizers) to release nutrients to crops for increased sustainable production in an eco-friendly pollution free environment.

G. Nammalvar was a supporter and expert of organic farming. He was an agricultural scientist, environmental activist celebrated for his work on spreading Ecological farming & Organic farming. He was against the use of chemical fertilisers and pesticides. He trained hundreds of farmers in natural farming. Nammalvar was the author of several Tamil and English books on natural farming, pesticides &fertilisers and was featured in magazines & television programs. He founded the Nammalvar Ecological Foundation for Farm Research and Global Food Security Trust or simply Vaanagam at Karur, Tamilnadu. He developed social forest at Ammankurai and the Kolunji Ecological Farm in Pudukottai. He and his friends made a 10-acre barren land into fertile cultivable land in the dry Pudukottai district. He planted 52 varieties of trees in the same waste land extending in 20 acres. His organization 'Kudumbam' preserves and regenerates hundreds of native flora and fauna, in order to ensure a sustainable livelihood.

Solid Waste Management

Every day, tonnes of solid wastes are disposed of at landfill sites. Tis waste comes from homes, offices, industries and various other agricultural related activities. These landfill sites produce foul smell if waste is not stored and treated properly. When hazardous wastes like pesticides, batteries containing lead,

cadmium, mercury or zinc, cleaning solvents, radioactive materials, e-waste and plastics are mixed up with paper and other scraps and burnt, they produce gases such as dioxins. These gases are toxic and carcinogenic. These pollute the surrounding air, ground water and can seriously affect the health of humans,wildlife and our environment. Te following are major sources of solid waste (Table 13.1).

Dr. Sultan Ahmed Ismail is an Indian soil biologist and ecologist from Tamil Nadu. His work has centered on techniques for recycling biodegradable waste into fertiliser using varieties of earthworms, and on soil bioremediation.

Dr. Ismail received a D.Sc. in Zoology from the University of Madras for his research on the role of earthworms in soil ecology and waste management. He works on vermicomposting as a sustainable ecological practice. He has been instrumental in introducing as well as spreading awareness on environmental issues, solid waste management, vermicomposting, organic farming, vermitech and waste management to several educational institutions, industries and organic farmers in India and abroad.

Solid Waste management includes the activities and actions required to manage waste from its inception to its final disposal. This includes the collection, transport, treatment and disposal of waste, together with monitoring and regulation of the waste management process. It is all about how solid waste can be changed and used as a valuable resource.

Case Study: The Corporation of Chennai looks after clearance and management of solid waste in Chennai. Every day around 5400 Metric Tonnes (MT) of garbage is collected from the city. Door to door collection of garbage is done in most zones apart from sweeping, collecting, and storing the waste in the specified bins. At present garbage generated in Chennai is dumped at two sites. Proposals are there for remediation of the existing landfill or scientific closure and to have integrated waste processing facilities with waste to energy plants as one of the components at the existing Kodungaiyur and Perungudi sites.

Waste management practices

a) Source segregation
b) Composting
c) Vermicomposting
d) Biogas generation
e) Incineration

1. Aerobic 2. Anaerobic

Waste category	Source

Residential	Food wastes, plastics, paper, glass, leather, cardboard, metals, yard wastes, ashes, tires, batteries, old mattresses
Industrial	Packaging wastes, ashes, chemicals, cans plastics, metal parts
Commercial	Thin and thick plastics, food wastes, metals, paper, glass, wood, cardboard materials
Institutional	Wood, paper, metals, cardboard materials, electronics
Construction and Demolition	Steel materials, concrete, wood, plastics, rubber, copper wires, dirt and glass.
Agriculture	Agricultural wastes, spoiled food, pesticide containers
Biomedical	Syringes, bandages, used gloves, catheter, urine bags, drugs, paper plastics, food wastes, sanitary napkins and diapers, chemicals.
E-Waste	Electronic items like used TVs, transistors, tape recorders, computer cabinets, mother boards, CDs, cassettes, mouse, wires, cords, switches, chargers.

Radioactive waste

Radioactive wastes are generated during various operations of the nuclear power plant. Radioactive waste can be in gas, liquid or solid form, and its level of radioactivity can vary. The waste can remain radioactive for a few hours or several months or even hundreds of thousands of years. Depending on the level and nature of radioactivity, radioactive wastes can be classified as exempt waste, Low and Intermediate level waste and High Level Waste.

Radioactive waste management

Radioactive waste management involves the treatment, storage, and disposal of liquid, airborne, and solid effluents from the nuclear industry.

Do you Know?

The Three Mile Island (Pennsylvania, UnitedStates), Chernobyl(Pripyat, Ukraine) andFukushima Daiichi(Ōkuma, Japan) are nuclear disastersthe world has seen in the recent period.

Methods of disposal of radioactive wastes are

1. Limit generation - Limiting the generation of waste is the first and most important consideration in managing radioactive wastes.
2. Dilute and disperse - For wastes having low radioactivity, dilution and dispersion are adopted.
3. Delay and decay - Delay and decay is frequently an important strategy because much of the radioactivity in nuclear reactors and accelerators is very short lived.

4. Concentrate and confine process -Concentrating and containing is theobjective of treatment activities for longer-lived radioactivity. The waste is contained in corrosion resistant containers and transported to disposal sites. Leaching of heavy metals and radionuclides from these sites is a problem of growing concern.

Control and Management

Three ways are employed to manage nuclear wastes

- **Spent Fuel Pools:** The spent fuel discharged from the reactors is temporarily stored in the reactor pool. The Spent fuel rods are used in stored cooling ponds. They protect the surroundings from radiation and absorb the heat generated during radioactive decay.
- **Vitrification method**: This prevents reaction or degradation of nuclear waste for extended periods of time and encased in dry cement caskets.
- **Geological Repositories:** A deep geological repository is a nuclear waste repository excavated deep within a stable geologic environment. It is suited to provide a high level of long-term isolation and containment without future maintenance. In India at Tarapur and Kalpakkam, a wet storage facility of Spent Fuel is the main mode of storage.

Medical waste

Any kind of waste that contains infectious material generated by hospitals, laboratories, medical research centers, Pharmaceutical companies and Veterinary clinics are called medical wastes.Medical wastes contain body fluids like blood, urine, body parts and other contaminants, culture dishes, glassware's, bandages, gloves, discarded needles, scalpels, swabs and tissues.

- ✓ **Management:** The safe and sustainable management of biomedical waste is the socialand legal responsibilities of people working in healthcare centers.
- ✓ **Waste disposal:** Involved by incineration, chemical disinfection, autoclaving, encapsulation, microwave irradiation are methods of waste disposals. Final disposal includes landfill and burying as per norms inside premises.

E-Waste

Electronic waste or e-waste describes discarded electrical electronic devices as well as any refuse created by discarded electronic devices and components and substances involved in their manufacture or use. Their disposal is a growing problem because electronic equipment frequently contains hazardous substances. In a personal computer, for example, there may be lead (Pb) in the cathode ray tube (CRT) and soldering compound, mercury (Hg) in switches and housing, and cobalt (Co) in steel components, among other equally toxic substances. E-wastes are

basically PCB (Polychlorinated biphenyl) based, which are non-degradable (Fig.13.7).

Used electronics which are destined for reuse, resale, salvage, recycling, or disposal are also considered e-waste. Unauthorized processing of e-waste in developing countriescan lead to adverse human health effects and environmental pollution.Recycling and disposal of e-waste may involve significant risk to the health of workers and communities in developed countries and great care must be taken to avoid unsafe exposure in recycling operations and leaking of materials such as heavy metals from landfills and incinerator ashes.

Plastic Waste - Solutions and Remedies

Plastics are low molecular weight organic polymers that are non-degradable in the natural environment. They are used in several items, including cars, bulletproof vests, toys, hospital equipment, carry bags and food containers. Packaging materials used in supermarkets, retail outlets, manufacturing industries, households, hotels, hospitals, restaurants and transport companies are major contributors to plastic waste generation. Plastic waste constitutes a major part of municipal solid waste.

- Remedies: '4R'- Refuse, Reduce, Reuse and Recycle mantra is the best available remedy for plastic waste pollution.
- Tamil Nadu State government successfully implemented the ban on single use plastics from 1st January 2019.

Global Environment Change

Green House Effect and Global warming

- Natural environment and climate are dynamic and keep changing over course of time. But with human population growth, industrialization and associated anthropological activities the changes are more pronounced and impactful in a much shorter time span, thus resulting in drastic Global environmental change.

- Large-scale changes of global environment can lead to hazards, which may include climate change, stratospheric ozone depletion, changesin ecosystems due to loss of biodiversity, changes in hydrological systems and the supplies of freshwater, land degradation, urbanization, and stress on food-producing systems.

- Greenhouse gases (GHG) water vapour, carbon dioxide, methane, nitrous oxide, ozone and some artificial chemicals such as chlorofuorocarbons (CFCs) causes greenhouse effect. The absorbed energy warms the atmosphere and the surface of the Earth.

- The large-scale global warming will have significant impact on people and nature. As global average temperatures rise, precipitation patterns could be affected. Extreme wet and dry conditions can be expected (flooding and desertification). Coastal areas shall become more vulnerable to storm surges as sea level rises. Plant and animal species will migrate or disappear in response to climate change.

- Global warming can directly affect the flora and fauna. This could also result in shortage of food and even lead to food crisis; and affect the health of the people and organisms.

Climate change threatens NilgiriTahr: The endangered wild goat could loseapproximately 60 % of its habitat, startingfrom the 2030s. (The Hindu, 12.08.2018)

The UNO has several measures to control or reduce pollution. Through various conventions organized by UNO, the countries assured to take steps to control or reduce emissions by factories and automobiles.

Major International Environmental Conventions

- 1972: UN conference on Human environment, Stockholm, Sweden
- 1972: UN environment programme (UNEP), Stockholm, Sweden
- 1987: Montreal Protocol, Vienna
- 1989: Intergovernmental panel on climate change, Geneva, Switzerland.
- 1992: Earth summit, Rio de Janeiro. Agenda 21, otherwise called Rioconference, Brazil
- 1997: Kyoto Protocol, Japan
- 2002: World Summit on Sustainable Development, Johannesburg, SouthAfrica
- 2003: World climate change conference, Moscow, Russia
- 2012: UN Conference on SustainableDevelopment, Rio de Janeiro
- 2015: UN Sustainable DevelopmentSummit, New York
- 2016: Montreal Protocol amendment atKigali, Rwanda
- 2017: The COP23 climate change summitin Bonn, Germany
- 2018: UN climate change conference, Katowice, Poland

Impact on Specific Ecosystems

Marine Ecosystem

The marine ecosystem (Fig. 13.8) is the source of fish, see weeds and other marine products. With the advent of intensive fishing by using giant nets and mechanized boats, fish catch has dropped significantly.

Ozone Depletion

At about 15 and 30 kilometers from the ground level, the earth's atmosphere has a thin layer of ozone, which absorbs ultraviolet sunlight. Ozone is found in the layer of the atmosphere called the Stratosphere. It acts as a protective covering that absorbs ultraviolet (UV) radiation from the sun. The ozone molecule (O3) consists of three oxygen atoms. It is formed when atmospheric oxygen (O2) on exposure to solar radiation breaks into two oxygen atoms; each atom then joins up with a single oxygen atom. The ozone molecule is unstable. It soon decays again to form molecular oxygen. Tis cycle is a continuous process in the upper reaches of the stratosphere.

World Ozone Day

September 16 has been designated by the United Nations as the International Day for the Preservation of the Ozone Layer.The ozone layer was discovered in 1913 by the French physicists Charles Fabry and Henri Buisson.

Causes and effects of ozone layer depletion

Causes: Ozone layer depletion mainly occurs by anthropogenic actions.The excessive release of chlorine and bromine from man-made compounds such as chlorofuorocarbons (CFCs) causes ozone layer depletion. CFCs, methyl chloroform, carbon tetrachloride, hydrochlorofuorocarbons,hydrobromofuorocarbonsand methyl bromide are found to have direct impact on the depletion of the ozone layer. These are categorized as ozone-depleting substances (ODS).

Effects: UV rays may penetrate deep into the skin and can lead to premature skin aging and wrinkling of skin; suppression of the immune system, skin cancer (melanoma) and chronic effects leading to eye damage. DNA damagecan result from free radicals and reactive oxygen and photons can damage the DNA itself.

Control: Ozone layer depletion can be controlled by

1. Phase down or ban the use of CFCs (CFC free refrigerants).
2. Minimizing the use of chemicals such as halons and halocarbons.
3. Creating awareness about ozone depleting agents.

Ozone hole (in purple colour), is the area above Antarctica, where the ozone layer is the thinnest.Ozone thickness is given in Dobson unit (see carefully the scale shown in colour from violet to red). The ozone hole over Antarctica develops each year between late August and early October. Courtesy: NASA

Deforestation

Deforestation is the destruction of forests in order to clear the land and make it available for other uses. Forests cover about 30 percent of the world's landmass. But due to deforestation it is estimated that the earth loses 18.7 million acres of forests per year. In 2016, global tree cover loss reached a record of 29.7 million hectares.Common methods of deforestation are burning trees and clear cutting.

People's Participation in Conservation of Forests

People's participation is vital in forest conservation, especially those living in them or close to the forest. This is referred to as Community forestry, which varies widely in legal, political and cultural settings and the term covers a wide range of experiences and practices.The Bishnois, who are known conservators of their forest, were inspiration to many people's participatory movements for Environmental protection in India. The **Chipko movement** resisted the destruction of forests of India in the 1970s. **SunderlalBahuguna**was the leader of this movement. People in the movement hugged the trees, and prevented felling of trees by contractors.

The 'Forest man of India', **JadavPayeng** who created 1,360 acres of dense and defiant forest was born in Arunasapori (a river island on the Brahmaputra). He had just completed his Class X exams in1979 when he started to sow the seeds and shoots on the eroded island covered with sand and silt. Thirty-six years later he had converted the once unproductive land into a forest. Payeng's forest is now home to five Royal Bengal tigers, over a hundred deer, wild boar, vultures, and several species of birds. For his remarkable initiative, the Jawaharlal Nehru University invited Payeng in 2012 on Earth Day and honoured him with the title of the 'Forest Man of India'. Later, the President APJ Abdul Kalam felicitated him with a cash award in Mumbai. The same year, he received the 'Padma Shri'.

The Indian Constitution also stresses on the importance of the role of the People in protecting their environment.

Amrita Devi was a brave lady from Khejarli Village of Jodhpur District, Rajasthan. She sacrificed her life to maintain Bishnoi Dharma. In 1730, Maharaja Abhay Singh, ruler of Marwar, Rajasthan state wanted to log green Khejri (Prosopis cineraria) trees to burn lime for the construction of his new palace. Since there was a lot of greenery in the Bishnoi villages even in the middle of Tar Desert, the king ordered his men to get the wood from Khejri trees. When she came to know about the cutting of trees by the King's men, she and many others had hugged the Khejri trees to save from cutting. But king's men killed Amrita Devi along with more than 363 other Bishnois. It was a Tuesday, black Tuesday in Khejarli. Tis incident took place to save trees and is recorded in India's history. To commemorate her bravery, the Government of Rajasthan and Madhya Pradesh have initiated the prestigious state level award named as Amrita Devi BishnoiSmriti Award' for excellent contribution to the protection and conservation of wildlife.

Ecosan Toilets

About 150 liters of wastewater at an average is generated by an Indian individual daily, and a large amount of it is generated from toilets. Ecological sanitation (EcoSan) is a sustainable system for handling human excreta by using dry composting toilets. EcoSan toilets not only reduce wastewater generation but also generate the natural fertilizer from recycled human excreta, which forms an excellent substitute for chemical fertilizers. This method is based on the principle of recoveryand recycling of nutrients from excreta to create a valuable supply for agriculture. 'EcoSan' toilets are being used in several parts of India and Sri Lanka.

Unit – 6- Principles of Ecology

- Ecology
- Ecological factors
- Ecological adaptations
- Dispersal of seeds and fruits

Ecology is a division of biology which deals with the study of environment in relation to organisms. It can be studied by considering individual organisms, population, community, biome or biosphere and their environment. While observing our different environments, one can ask questions like

Why do plants or animals vary with places?
What are the causes for variation in biological diversity of different places?
How soil, climate and other physical features affect the flora and fauna or vice versa?

These questions can be better answered with the study of ecology. Ecology is essentially a practical science involving experiments, continuous observations to predict how organisms react to particular environmental circumstances and understanding the principles involved in ecology.

Ecology

The term "ecology" (oekologie) is derived from two Greek words – oikos (meaning house or dwelling place and logos meaning study) It was first proposed by Reiter (1868). However, the most widely accepted definition of ecology was given by Ernest Haeckel (1869).

Alexander von Humbolt - Father of Ecology Eugene P. Odum - Father of morden Ecology R.Misra - Father of Indian Ecology

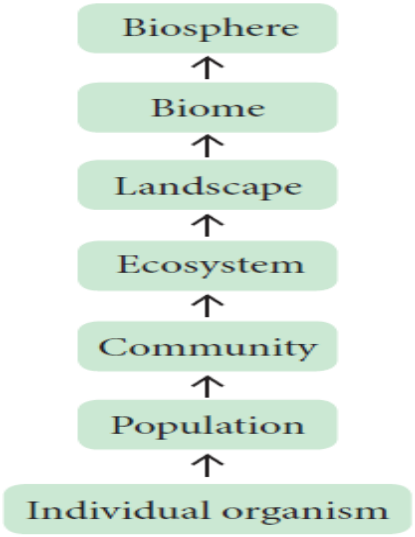
Definitions of ecology

"The study of living organisms, both plants and animals, in their natural habitats or homes." - Reiter (1885)

"Ecology is the study of the reciprocal relationship between living organisms and their environment." - Earnest Haeckel (1889)

Ecological hierarchy

The interaction of organisms with their environment results in the establishment of grouping of organisms which is called ecological hierarchy or ecological levels of organization. The basic unit of ecological hierarchy is an individual organism. The different hierarchy of ecological systems is illustrated below:



Branches of Ecology:

Ecology is mainly divided into two branches, they are autecology and synecology.

1. Autecology is the ecology of an individualspecies and is also called species ecology.
2. Synecology is the ecology of a population orcommunity with one or more species and alsocalled as community ecology.

Many advances and developments in the fieldecology resulted in various new dimensionsand branches. Some of the advanced fields areMolecular ecology, Eco technology, Statisticalecology and Environmental toxicology.

Habitat and Niche

Habitat

Habitat is a specific physical place or locality occupied by an organism or any species which has a particular combination of abiotic or environmental factors. But the environment of any community is called Biotope.

Niche

An ecological niche refers to an organism's place in the biotic environment and its functional role in an ecosystem. The term was coined by the naturalist Roswell Hill Johnson but Grinell (1917) was probably first to use this term. Thehabitat and niche of any organism is called Ecotope.

The differences between habitat and niche are as follows.

	HABITAT	NICHE
1.	A Specific physical space occupied by an organism (species)	A functional space occupied by an organism in the same eco-system
2.	Same habitat may be shared by many organisms (species)	A single niche is occupied by a single species
3.	Habitat specificity is exhibited by organism.	Organisms may. change their niche with time and season.

Applied ecology or environmental technology :

Application of the Science of ecology is otherwise called as Applied ecology or Environmental technology. It helps us to manage and conserve natural resources, particularly ecosystems, forest and wild life conservative and management. Environmental management involves Bio-diversity conservation, Ecosystem restoration, Habitat management, Invasive species management, Protected areas management and also help us plan landscapes and environmental impact designing for the futuristic ecology.

Ecological equivalents

Taxonomically different species occupying similar habitats (Niches) in different geographical regions are called Ecological equivalents.

Examples:

- Certain species of epiphytic orchids of Western Ghats of India differ from the epiphytic orchids of South America. But they are epiphytes.
- Species of the grass lands of Western Ghats of India differ from the grass species of temperate grass lands of Steppe in North America. But they are all ecologically primary producers and fulfilling similar roles in their respective communities.

Ecological factors

Many organisms, co-exist in an environment. The environment (surrounding) includes physical, chemical and biological components. When a component surrounding an organism affects the life of an organism, it becomes a factor. All such factors together are called environmental factors or ecological factors. These factors can be classified into living (biotic) and non-living (abiotic) which make the environment of an organism. However the ecological factors are meaningfully grouped into four classes, which are as follows:

i. Climatic factors
ii. Edaphic factors
iii. Topographic factors

iv. Biotic factors

We will discuss the above factors in a concise manner.

Flowers of poppy, chicory, dog rose and many other plants, blossom before the break of dawn (4 – 5 am), evening primrose open up with the onset of dusk (5 – 6 pm) due to diurnal rhythm

Climatic Factors

Climate is one of the important natural factors controlling the plant life. The climatic factors includes light, temperature, water, wind and fire.

a. Light

Light is a well known factor needed for the basic physiological processes of plants, such as photosynthesis, transpiration, seed germination and flowering. The portion of the sunlight which can be resolved by the human eye is called visible light. The visible part of light is made-up of wavelength from about 400 nm (violet) to 700 nm (red). The rate of photosynthesis is maximum at blue (400 – 500 nm) and red (600 – 700 nm). The green (500 – 600 nm) wave length of spectrum is less strongly absorbed by plants.

Effects of light on plants
Based on the tolerance to intensities of light, the plants are divided into two types.

They are

1. Heliophytes - Light loving plants.Example: Angiosperms.
2. Sciophytes - Shade loving plants.Example: Bryophytes and Pteridophytes.

In deep sea (>500m), the environment is dark and its inhabitants are not aware of the existence of celestial source of energy called Sun. What, then is their source of energy?

Palaeoclimatology–Helps to reconstruct past climates of our planet and flora, fauna and ecosystem in which they lived. Example: Air bubbles trapped in ice for tens of thousands of years with fossilized pollen, coral, plant and animal debris.

b. Temperature

Temperature is one of the important factorswhich affect almost all the metabolic activitiesof an organism. Every physiological process inan organism requires an optimum temperatureat which it shows the maximum metabolic rate.Three limits of temperature can be recognizedfor any organism. They are

1. Minimum temperature - Physiologicalactivities are lowest.
2. Optimum temperature - Physiologicalactivities are maximum.
3. Maximum temperature - Physiologicalactivities will stop.

Based on the temperature prevailing inan area, Raunkiaer classified the world's vegetation into the following four types. They are megatherms, mesotherms, microtherms and hekistotherms. In thermal springs and deep sea hydrothermal vents where average temperature exceed 100oc.

Based on the range of thermal tolerance, organisms are divided into two types.

1. Eurythermal: Organisms which can tolerate a wide range of temperature fluctuations.
   Example: Zostera (A marine Angiosperm) andArtemisiatridentata.

2. Stenothermal: Organisms which cantolerate only small range of temperaturevariations. Example: Mango and Palm(Terrestrial Angiosperms).

Mango plant donot and cannot grow in temperate countries like Canada and Germany.

Thermal Stratification

It is usually found in aquatic habitat. The change in the temperature profile with increasing depth in a water body is called thermal stratification. There are three kinds of thermal stratifications.

1. Epilimniotn – The upper layer of warmerwater.
2. Metalimnion – The middle layer with azone of gradual decrease in temperature.
3. Hypolimnion - The bottom layer of colderwater.

Temperature based zonation

Variations in latitude and altitude do affect the temperature and the vegetation on the earth surface. The latitudinal and altitudinal zonation of vegetation is illustrated below:

Latitude: Latitude is an angle which ranges from 00 at the equator to 900 at the poles.
Altitude: How high a place is located above the sea level is called the altitude of the place.

Timber line / Tree line : It is an imaginary line in a mountain or higher areas of land

that marks the level above which trees do not grow. The altitudinal limit of normal tree growth is about 3000 to 4000m.

Effects of temperature

The following physiological processes are influenced by temperature:

Temperature affects the enzymatic actionof all the bio-chemical reactions in a plantbody.

- It influences CO2 and O2 solubility in thebiological systems. Increases respirationand stimulates growth of seedlings.
- Low temperature with high humidity canspread diseases to plants.
- The varying temperature with moisturedetermines the distribution of thevegetation types.

c. Water

Water is one of the most important climaticfactors. It affects the vital processes of all livingorganisms. It is believed that even life hadoriginated only in water during the evolution ofEarth. Water covers more than 70% of the earth's surface. In nature, water is available to plants inthree ways. They are atmospheric moisture,precipitation and soil water.

Evergreen forests – Found where heavy rainfall occurs throughout the year.
Sclerophyllous forests –Found where heavy rainfall occurs during winter and low rainfall during summer.

The productivity and distribution of plants depend upon the availability of water. Further the quality of water is also important especially for the aquatic organisms. The total amount of water salinity in different water bodies are :i).5% in inland water (Fresh water) ii).30 – 35% in sea water and iii).More than 100% in hypersaline water (Lagoons)
Based on the range of tolerance of salinity, organisms are divided into two types.

1. Euryhaline: Organisms which can live inwater with wide range of salinity. Examples:Marine algae and marina angiosperms
2. Stenohaline: Organisms which can withstand only small range of salinity. Example: Plants ofestuaries.

Terminology		Environmental factor
Stenothermal	Eurythermal	Temperature
stenohaline	Euryhaline	Salinity
Stenoeciouss	Euryoecious	Habitat Selection(niche)
Stenophagic	Euryphagic	Water

Stenophagic	Euryphagic	Food
Stenobathic	Eurybathic	Depth of Water/Habitat

Examples of tolerance to toxicity

i. Soyabean and tomato manage to tolerate presence of cadmium poisoning by isolating cadmium and storing into few group of cells and prevent cadmium affecting other cells .
ii. Rice and Eichhornia (water hyacinth) tolerate cadmium by binding it to their proteins.

These plants otherwise can also be used to remove cadmium from contaminated soil, this is known as Phytoremediation.

d. Wind

Air in motion is called wind. It is also a vital ecological factor. The atmospheric air contains a number of gases, particles and other constituents. The composition of gases in atmosphere is as follows: Nitrogen -78%, Oxygen -21%, Carbon-di-oxide - 0.03%, Argon and other gases - 0.93%. The other components of wind are water vapour, gaseous pollutants, dust, smoke particles, micro-organisms, pollen grains, spores, etc. Anemometer is the instrument used to measure the speed of wind.

Green House Effect Albedo Effect

Gases let out to atmosphere causes climatic change. Emission of dust and aerosols (small solids or liquid particles in suspension in the atmosphere) from industries, automobiles, forest fire, So2 and DMS (dimethyl sulphur) play an important role in disturbing the temperature level of any region. Aerosols with small particles is reflecting the solar radiation entering the atmosphere. This is known as Albedo effect. So it reduces the temperature (cooling) limits, photosynthesis and respiration. The sulphur compounds are responsible for acid rain due to acidification of rain water and destroy the ozone.

Effects of wind

- Wind is an important factor for the formation of rain
- Causes wave formation in lakes and ocean, which promotes aeration of water
- Strong wind causes soil erosion and reduces soil fertility
- Increases the rate of transpiration
- Helps in pollination in anemophilous plants
- It also helps in dispersal of many fruits, seeds, spores, etc.
- Strong wind may cause up-rooting of big trees
- Unidirectional wind stimulates the development of flagforms in trees.

e. Fire

Fire is an exothermic factor caused due to thechemical process of combustion, releasing heat and light. It is mostly man-made and some-times develops naturally due to the frictionbetween the tree surfaces. Fire is generallydivided into

1. Ground fire – Which is flameless andsubterranean.
2. Surface fire – Which consumes the herbsand shrubs.
3. Crown fire – Which burns the forest canopy.

Effects of fire

- Fire has a direct lethal effect on plants
- Burning scars are the suitable places for theentry of parasitic fungi and insects
- It brings out the alteration of light, rainfall,nutrient cycle, fertility of soil, pH, soil floraand fauna
- Some fungi which grow in soil of burnt areascalled pyrophilous.
  Example: Pyronemaconfluens.

Indicators of fire – Pteris (fern) and Pyronema (fungus) indicates the burnt up and fire disturbed areas. So they are called indicators of fire.

Fire break – It is a gap made in the vegetation that acts as a barrier to slow down or stop the progress of fire.
A natural fire break may occur when there is a lack of vegetation such as River, lake and canyon found in between vegetation may act as a natural fire break.

Rhytidome: It is the structural defense by plants against fire .The outer bark of trees which extends to the last formed periderm is called Rhytidome. It is composed of multiple layers of suberized periderm, cortical and phloem tissues. It protects the stem against fire , water loss, invasion of insects and prevents infections by microorganisms.

Edaphic factors

Edaphic factors, the abiotic factors related to soil, include the physical and chemical composition of the soil formed in a particular area. The study of soils is called Pedology.

The soil

Soil is the weathered superficial layer of the Earth in which plants can grow. It is a complex composite mass consisting of soil constituents, soil water, soil air and soil organisms, etc.

Soil formation

Soil originates from rocks and develops gradually at different rates, depending upon the ecological and climatic conditions. Soil formation is initiated by the weathering process. Biological weathering takes place when organisms like bacteria, fungi, lichens and plants help in the breakdown of rocks through the production of acids and certain chemical substances.

Soil types

Based on soil formation (pedogenesis), the soils are divided into

1. Residual soils –These are soils formed byweathering and pedogenesis of the rock.
2. Transported soils – These are transportedby various agencies.

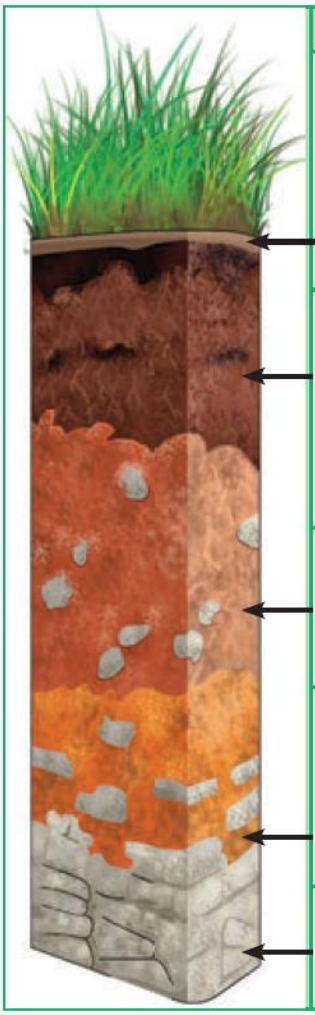
The important edaphic factors which affect vegetation are as follows:

1. Soil moisture: Plants absorbs rain waterand moisture directly from the air
2. Soil water: Soil water is more importantthan any other ecological factors affecting the distribution of plants. Rain is the main source of soil water. Capillary water held between pore spaces of soil particles and angles between them is the most important form of water available to the plants.
3. Soil reactions: Soil may be acidic oralkaline or neutral in their reaction. pH valueof the soil solution determines the availabilityof plant nutrients. The best pH range of the soilfor cultivation of crop plants is 5.5 to 6.8.
4. Soil nutrients: Soil fertility and productivityis the ability of soil to provide all essentialplant nutrients such as minerals and organicnutrients in the form of ions.
5. Soil temperature: Soil temperature of anarea plays an important role in determiningthe geographical distribution of plants. Lowtemperature reduces use of water and soluteabsorption by roots.
6. Soil atmosphere: The spaces left betweensoil particles are called pore spaces whichcontains oxygen and carbon-di-oxide.
7. Soil organisms: Many organisms existingin the soil like bacteria, fungi, algae,protozoans, nematodes, insects, earthworms, etc. are called soil organisms.
8. **Soil Profile**

9. Soil is commonly stratified into horizons at different depth. These layers differ in their physical, chemical and biological properties. This succession of super-imposed horizons is called soil profile.

	Soil type	Size	Realativeprorportion
1	Clayey soil	Less than 0.002mm	50% clay and 50% silt (colt / heavy soil)

2.	slit soil	0.002 to 0.02mm	90% slit and 10% sand
3.	Loamy soil	0.002 to 2mm	70% sand and 30% clay/ silt or both (Garden soil)
4.	Sandy soil	0.2 to 2mm	85% sand and 15% clay (light soil)



Horizon	Description
O–Horizon (Organic horizon) Humus	It consists of fresh or partially decomposed organic matter. O1 – Freshly fallen leaves, twigs, flowers and fruits O2 – Dead plants, animals and their excreta decomposed by micro-organisms. Usually absent in agricultural and deserts.
A–Horizon (Leached horizon) Topsoil - Often rich in humus and minerals.	It consists of top soil with humus, living creatures and in-organic minerals. A1 – Dark and rich in organic matter because of mixture of organic and mineral matters. A2 – Light coloured layer with large sized mineral particles.
B-Horizon (Accumulation horizon) (Subsoil-Poor in humus, rich in minerals)	It consists of iron, aluminium and silica rich clay organic compounds.
C - Horizon (Partially weathered horizon) Weathered rock Fragments - Little or no plant or animal life.	It consists of parent materials of soil, composed of little amount of organic matters without life forms.
R – Horizon (Parent material) Bedrock	It is a parent bed rock upon which underground water is found .

Figure 6.7: Soil Profile

Types of soil particles

Based on the relative proportion of soil particles, four types of soil are recognized.

Loamy soil is ideal soil for cultivation. It consists of 70% sand and 30% clay or silt or both. It ensures good retention and proper drainage of water. The porosity of soil provides adequate aeration and allows the penetration of roots.

Based on the water retention, aeration and mineral contents of soil, the distribution of vegetation is divided into following types.

1. Halophytes: Plants living in saline soils

2. Psammophytes: Plants living in sandy soils
3. Lithophytes: Plants living on rocky surface
4. Chasmophytes: Plants living in rocky crevices
5. Cryptophytes: Plants living below the soilsurface
6. Cryophytes: Plants living in ice surface
7. Oxylophytes: Plants living in acidic soil
8. Calciphytes: Plants living in calcium richalkaline soil.

Hollard –Total soil water content Chresard –Water available to plants Echard – Water not available to plants

Topographic factors

The surface features of earth are called topography. Topographic influence on the climate of any area is determined by the interaction of solar radiation, temperature, humidity, rainfall, latitude and altitude. It affects the vegetation through climatic variations in small areas (micro climate) and even changes the soil conditions. Topographic factors include latitude, altitude, direction of mountain, steepness of mountain etc.

a. Latitudes and altitudes

Latitudes represent distance from the equator.Temperature values are maximum at the equator and decrease gradually towards poles. Differenttypes of vegetation occur from equator to poleswhich are illustrated below.

Height above the sea level forms the altitude. At high altitudes, the velocity of wind remains high, temperature and air pressure decrease while humidity and intensity of light increases. Due to these factors, vegetation at different altitudes varies, showing distinct zonation.

b. Direction of Mountain

North and south faces of mountain or hill possess different types of flora and fauna because theydiffer in their humidity, rainfall, light intensity,light duration and temperature regions.

Ecotone - The transition zone between two ecosystems. Example: The border between forest and grassland. Edge effect – Those species are found in the ecotone areas are due to the effect of environment of the two habitats. This is called edge effect. Example: Owl in the ecotone area between forest and grassland.

The two faces of the mountain or hill receive different amount of solar radiation, wind action and rain. Of these two faces, the windward region possesses good vegetation due to heavy rains and the leeward region possesses poor vegetation due to rain shadows (rain deficit).

Similarly in the soil of aquatic bodies like ponds the center and edge possess different depth of water due to soil slope and different wave actions in the water body. Therefore, different parts of the same area may possess different species of organisms.

c. Steepness of the mountain

The steepness of the mountain or hill allowsthe rain to run off. As a result the loss of watercauses water deficit and quick erosion of the topsoil resulting in poor vegetation. On the otherhand, the plains and valley are rich in vegetationdue to the slow drain of surface water and betterretention of water in the soil.

Biotic factors

The interactions among living organisms such as plants and animals are called biotic factors, which may cause marked effects upon vegetation. The effects may be direct and indirect and modifies the environment. The plants mostly which lives together in a community and influence one another. Similarly, animals in association with plants also affect the plant life in one or several ways. The different interactions among them can be classified into following two types they are positive interaction and negative interaction

Positive interactions

When one or both the participating species are benefited, it is positive interaction. Examples; Mutualism and Commensalism.

a.Mutualism: It is an interaction betweentwo species of organisms in which both arebenefitted from the obligate association. Thefollowing are common examples of mutualism.

Nitrogen fixation

Rhizobium (Bacterium) forms nodules in the roots of leguminous plants and lives symbiotically. The Rhizobium obtains food from leguminous plant and in turn fixes atmospheric nitrogen into nitrate, making it available to host plants.

Other examples:

- Water fern (Azolla) and Nitrogen fixing Cyanobacterium (Anabaena).
- Anabaena present incoralloid roots of Cycas.(Gymnosperm)

- ❖ Cyanobacterium (Nostoc) found in thethalloid body of Anthoceros.(Bryophytes)
- ❖ Wasps present in fruits of fig.
- ❖ Lichen is a mutual association of an algaand a fungus.
- ❖ Roots of terrestrial plants and fungal hyphae- Mycorrhiza

b. Commensalism:

It is an interaction between two organisms in which one is benefitted andthe other is neither benefitted nor harmed.The species that derives benefit is called the commensal, while the other species is called the host. The common examples of commen salismare listed below:

	Interaction type	Combination		Effects	Examples
1.Positive interaction					
1	**Mutualism**	(+)	(+)	Both species benefitted	Lichen, *Mycorrhiza* etc.
2	**Commensalism**	(+)	(0)	One species is benefitted and the other species is neither benefitted nor harmed	orchids, Lianas etc.
2.Negative interaction					
4	**Predation**	(+)	(-)	One species benefitted, the other species are harmed	*Drosera, Nepenthes* etc.
5	**Parasitism**	(+)	(-)	One species benefitted, the other species are harmed	*Cuscuta, Duranta, Viscum* etc.
6	**Competition**	(-)	(-)	Harmful for both	Grassland species
7	**Amensalism**	(-)	(0)	Harmful for one, but the other species are unaffected	*Penicillium* and *Staphylo coccus*

(+) Benefitted, (-) Harmed (0)Unaffected

Table 6.4: Different interactions of plant

Epiphytes

The plants which are found growing on other plants without harming them are called epiphytes. They are commonly found in tropical rain forest.

The epiphytic higher plant (Orchids) gets its nutrients and water from the atmosphere with the help of their hygroscopic roots which contain special type of spongy tissue called Velamen. So it prepares its own food and does not depend on the host. They use the host plant only for support and does not harm it in any way.

- ❖ Many orchids, ferns, lianas, hanging mosses, Peperomia, money plant and *Usnea* (Lichen)are some of the examples of epiphytes.
- ❖ Spanish Moss –Tillandsia grows on the barkof Oak and Pine trees.

Proto Cooperation

An interaction between organisms of different species in which both organisms benefit but neither is dependent on the relationship. Example: Soil bacteria / fungi and plants growing in the soil.

Negative interactions

When one of the interacting species is benefitted and the other is harmed, it is called negative interaction . Examples: predation, parasitism, competition and amensalism.

a. Predation: It is an interaction between twospecies, one of which captures, kills and eatsup the other. The species which kills is calleda predator and the species which is killed iscalled a prey. The predator is benefitted whilethe prey is harmed.

Examples:

- A number of plants like Drosera (Sun dew Plant), Nepenthes (Pitcher Plant), Diaonaea (Venus fly trap), Utricularia (Bladder wort) and Sarracenia are predators which consume insects and other small animals for their food as a source of nitrogen. They are also called as insectivorous plants.
- Many herbivores are predators. Cattles, Camels, Goats etc., frequently browse onthe tender shoots of herbs, shrubs and trees. Generally annuals suffer more thanthe perennials. Grazing and browsing maycause remarkable changes in vegetation. Nearly 25 percent of all insects are known as phytophagous(feeds on plant sap and other parts of plant)
- Many defense mechanisms are evolved toavoid their predations by plants. Examples: Calotropis produces highly poisonous cardiacglycosides, Tobacco produces nicotine, coffee plants produce caffeine, Cinchona plant produces quinine. Thorns of Bougainvillea, spines of Opuntia, and latex of cacti alsoprotect them from predators.

b. Parasitism:

It is an interaction between twodifferent species in which the smaller partner(parasite) obtains food from the larger partner(host or plant). So the parasitic species isbenefited while the host species is harmed. Based on the host-parasite relationship, parasitism isclassified into two types they are holoparasiteand hemiparasite.

Holoparasites

The organisms which are dependent upon the host plants for their entire nutrition are called Holoparasites. They are also called total parasites.

Examples:

- Cuscuta is a total stem parasite of thehost plant Acacia, Duranta and manyother plants. Cuscuta even gets flowerinducing hormone from its host plant.

- ❖ Balanophora, orobanche and Refflesiaare the total root parasites found onhigher plants.

Hemiparasites

The organisms which derive only water and minerals from their host plant while synthesizing their own food by photosynthesis are called Hemiparasites. They are also called partial parasites.

Examples:

- Viscum and Loranthus are partial stemparasites.
- Santalum (Sandal Wood) is a partial rootparasite.

The parasitic plants produce the haustorialroots inside the host plant to absorb nutrients from the vascular tissues of host plants.

c. Competition:

It is an interaction between two organisms or species in which both theorganisms or species are harmed. Competitionis the severest in population that has irregular distribution. Competition is classified intointraspecific and interspecific.

1. Intraspecific competition: It is an interactionbetween individuals of the same species. This competition is very severe because all the members of species have similar requirements of food, habitat, pollination etc. and they also have similar adaptations to fulfill their needs.
2. Interspecific competition: It is an interactionbetween individuals of different species. In grassland, many species of grasses grow well as there is little competition when enough nutrients and water is available. During drought shortage of water occurs . A life and death competition starts among the different species of grass lands. Survival in both these competitions is determined by the quantity of nutrients, availability of water and migration to new areas. Different species of herbivores, larvae and grass hopper competing for fodder or forage plants. Trees, shrubs and herbs in a forest struggle for sunlight, water and nutrients and also for pollination and dispersal of fruits and seeds. The Utricularia (Bladderwort) competes with tiny fishes for small crustaceans and insects.

d. Amensalism:

It is an interspecific interactionin which one species is inhibited while the otherspecies is neither benefitted nor harmed. Theinhibition is achieved by the secretion of certainchemicals called allelopathic substances.Amensalism is also called antibiosis.

- Penicillium notatum produces penicillin toinhibit the growth of a variety of bacteriaespecially Staphylococcus.
- Trichoderma inhibits the growth of fungusAspergillus.
- Roots and hulls of Black Walnut Juglansnigra secretes an alkaloid Junglonewhichinhibits the growth of seedlings of Apple,Tomato and Alfalfa around it.

Interspecific interactions/ Co-evolutionary dynamics

i. Mimicry: It is a phenomenon in whichliving organism modifies its form, appearance,structure or behavior and looks like anotherliving organism as a self defence and increasesthe chance of their survival. Floral mimicryis for usually inviting pollinators but animalmimicry is often protective. Mimicry is a resultof evolutionary significance due to shape andsudden heritable mutation and preservation ofnatural selection.
Phyllium frondosum – leaf insect, anotherexample of protective mimicry.

ii. Myrmecophily: Sometimes, ants take theirshelter on some trees such as Mango, Litchi,Jamun, Acacia etc. These ants act asbody guards of the plants against any disturbing agent and the plants in turn provide food and shelter to these ants. This phenomenon is known as Myrmecophily. Example: Acacia and acacia ants.

iii. Co-evolution: The interaction between organisms, when continues for generations, involves reciprocal changes in genetic and morphological characters of both organisms. This type of evolution is called Co-evolution. It is a kind of co- adaptation and mutual change among interactive species.

Examples:

- Corolla length and proboscis length ofbutterflies and moths (Habenaria and Moth).
- Bird's beak shape and flower shape and size.
- More examples: Horn bills and birdsof Scrub jungles,Slit size of pollinia ofApocynaceae members and leg size ofinsects.

Kairomone released from Pieris *rapae* caterpillar exposed to wild Radish gets the capacity to transmit defence induced by predator to progeny of wild radish. Transmission capacity of defence induced by predator to progeny of wild radish.

Ecological adaptations

The modifications in the structure of organisms to survive successfully in an environment are called adaptations of organisms. Adaptations help the organisms to exist under the prevailing ecological habitat. Based on the habitats and the

corresponding adaptations of plants, they are classified as hydrophytes, xerophytes, mesophytes, epiphytes and halophytes.

Hydrophytes

The plants which are living in water or wet places are called hydrophytes. According to their relation to water and air, they are sub-divided into following categories: i) Free floating hydrophytes, ii) Rooted- floating hydrophytes, iii) Submerged floating hydrophytes, iv) Rooted -submerged hydrophytes, v) Amphibious hydrophytes.

i. Free floating hydrophytes: These plantsfloat freely on the surface of water. Theyremain in contact with water and air, but notwith soil. Examples: Eichhornia, Pistia andWolffia (smallest flowering plant).
ii. Rooted floating hydrophytes: In theseplants, the roots are fixed in mud, but their leaves and flowers are floating on the surface of water. These plants are in contact with soil, water and air. Examples: Nelumbo, Nymphaea, Potomogeton and Marsilea.
iii. Submerged floating hydrophytes: Theseplants are completely submerged in water andnot in contact with soil and air. Examples:Ceratophyllum and Utricularia.
iv. Rooted- submerged hydrophytes: Theseplants are completely submerged in waterand rooted in soil and not in contact with air.Examples: Hydrilla, Vallisneria and Isoetes.
v. Amphibious hydrophytes (Rooted emergenthydrophytes): These plants are adapted to bothaquatic and terrestrial modes of life. They grow in shallow water. Examples: Ranunculus, Typha and Sagittaria.

Lotus seeds showing highest longevity in plant kingdom.

Hygrophytes: The plants which can grow in moist damp and shady places are called hygrophytes. Examples: Habenaria (Orchid), Mosses (Bryophytes), etc.

Morphological adaptations of Hydrophytes:

In root

- Roots are totally absent in Wolffia andSalvinia or poorly developed in Hydrilla or well developed in Ranunculus.
- The root caps are replaced by root pockets.Example: Eichhornia

In stem

- The stem is long, slender, spongy and flexible in sub-merged forms.

- In free floating forms the stem is thick, shortstoloniferous and spongy; and in rootedfloating forms, it is a rhizome .
- Vegetative propagation is through runners,stolon, stem and root cuttings , tubers,dormant apices and offsets.

In leaves

- The leaves are thin, long and ribbon shaped in Vallisneria or long and linear in Potamogetonor finely dissected in Ceratophyllum
- The floating leaves are large and flat as inNymphaea and Nelumbo. In Eichhornia andTrapa petioles become swollen and spongy.
- In emergent forms, the leaves showheterophylly (Submerged leaves aredissected and aerial leaves are entire).Example: Ranunculus, Limnophilaheterophylla and Sagittaria

Anatomical adaptations

- Cuticle is either completely absent or ifpresent it is thin and poorly developed
- Single layer of epidermis is present
- Cortex is well developed with aerenchyma
- Vascular tissues are poorly developed. Inemergent forms vascular elements are welldeveloped.
- Mechanical tissues are generally absentexcept in some emergent forms. Pith cellsare sclerenchymatous.

Physiological adaptations of Hydrophytes:

- Hydrophytes have the ability to withstandanaerobic conditions.
- They possess special aerating organs.

Xerophytes

The plants which are living in dry or xericcondition are known as Xerophytes. Xerophytichabitat can be of two different types. They are:

a. Physical dryness: In these habitats, soil has alittle amount of water due to the inability of thesoil to hold water because of low rainfall.
b. Physiological dryness: In these habitats,water is sufficiently present but plants are unable to absorb it because of the absence of capillaryspaces. Example: Plants in salty and acidic soil.

Based on adaptive characters xerophytes are classified into three categories. They are Ephemerals, Succulents and Non succulent plants

i. Ephemerals:These are alsocalled droughtescapers or drought evaders. These plants complete their life cycle within a short period (single season).

These are not true xerophytes. Examples: Argemone, Mollugo, Tribulus and Tephrosia.

ii. Succulents: These are also called droughtenduring plants. These plants store water intheir plant parts during the dry period. Theseplants develop certain adaptive characters toresist extreme drought conditions. Examples:Opuntia, Aloe, Bryophyllum and Begonia.

iii. Non succulents: These are also calleddrought resistant plants (true xerophytes).They face both external and internal dryness.They have many adaptations to resist dryconditions. Examples: Casuarina, Nerium,Zizyphus and Acacia.

Morphological Adaptations
In root

- Root system is well developed and is greaterthan that of shoot system.
- Root hairs and root caps are also welldeveloped.

In Xerophytic plants with the leaves and stem are covered with hairs are called trichophyllous plants. Example: Cucurbits (Melothria and Mukia)

In stem

- Stems are mostly hard and woody. They maybe aerial or underground
- The stems and leaves are covered with waxcoating or covered with dense hairs.
- In some xerophytes all the internodes in thestem are modified into a fleshy leaf structurecalled phylloclades (Opuntia).
- In some of the others single or occasionallytwo internodes modified into fleshy greenstructure called cladode (Asparagus).
- In some the petiole is modified into a fleshyleaf like structure called phyllode (Acaciamelanoxylon).

a) A succulent xerophyte: Phylloclade – opuntia
b) Non succulent: Perennial – Capparis
c) Cladode of Asparagus
d) Phyllode – Acacia

In leaves

- Leaves are generally leathery and shiny toreflect light and heat.
- In some plants like Euphorbia, Acacia,Ziziphus and Capparis, the stipules aremodified into spines.
- The entire leaves are modified into spines(Opuntia) or reduced to scales (Asparagus).

Anatomical adaptations

- Presence of multilayered epidermis withheavy cuticle to prevent water loss due totranspiration.
- Hypodermis is well developed withsclerenchymatous tissues.
- Sunken shaped stomata are present only in thelower epidermis with hairs in the sunken pits.
- Scotoactive type of stomata found insucculent plants.
- Vascular bundles are well developed withseveral layered bundle sheath.
- Mesophyll is well differentiated intopalisade and spongy parenchyma.
- In succulents the stem possesses a waterstorage region.

Physiological adaptations

- Most of the physiological processes aredesigned to reduce transpiration.
- Life cycle is completed within a shortperiod (Ephemerals).

Mesophytes

The plants which are living in moderate conditions (neither too wet nor too dry) are known as mesophytes. These are common land plants. Example: Maize and *Hibiscus*.

Morphological adaptations

- Root system is well developed with rootcaps and root hairs
- Stems are generally aerial, stout and highlybranched.
- Leaves are generally large, broad, thin with different shapes.

Anatomical adaptations

- Cuticle in aerial parts are moderatelydeveloped.
- Epidermis is well developed and stomata are generally present on both the epidermis.
- Mesophyll is well differentiated into palisade and spongy parenchyma.
- Vascular and mechanical tissues are fairlydeveloped and well differentiated.

Physiological adaptations

- All physiological processes are normal.
- Temporary wilting takes place at room temperature when there is water scarcity.

Tropophytes are plants which behave as xerophytes at summer and behave as mesophytes (or) hydrophytes during rainy season.

Epiphytes

Epiphytes are plants which grow perched on other plants (Supporting plants). They use the supporting plants only as shelter and not for water or food supply. These epiphytesare commonly seen in tropical rain forests. Examples: Orchids, Lianas, Hanging Mosses and Money plant.

Morphological adaptations

- Root system is extensively developed. Theseroots may be of two types. They are Clingingroots and Aerial roots.

  Clinging roots fix the epiphytes firmly onthe surface of the supporting objects.

  Aerial roots are green coloured roots whichmay hang downwardly and absorb moisturefrom the atmosphere with the help of aspongy tissue called velamen.

- Stem of some epiphytes are succulent anddevelop pseudo bulb or tuber.
- Generally the leaves are lesser in numberand may be fleshy and leathery
- Myrmecophily is a common occurrencein the epiphytic vegetation to prevent thepredators.
- The fruits and seeds are very small andusually dispersed by wind, insects and birds.

Anatomical adaptations

- Multilayered epidermis is present. Inner tothe velamen tissue, the peculiar exodermislayer is present.
- Presence of thick cuticle and sunken stomata greatly reduces transpiration.
- Succulent epiphytes contain well developedparenchymatous cells to store water.

Physiological adaptations

Special absorption processes of water by velamen tissue.

Halophytes

- There are special type of Halophytic plants which grow on soils with high concentration of salts. Examples: Rhizophora, Sonneratia and Avicennia.
- Halophytes are usually found near the sea-shores and Estuaries. The soils are physically wet but physiologically dry. As plants cannot use salt water directly they require filtration of salt using physiological processes. This vegetation is also known as mangrove forest and the plants are called mangroves.

Morphological adaptations

- The temperate halophytes are herbaceousbut the tropical halophytes are mostly bushy
- In addition to the normal roots, many stiltroots are developed
- A special type of negatively geotropicroots called pneumatophores withpneumathodes to get sufficient aerationare also present. They are called breathingroots. Example: Avicennia
- Presence of thick cuticleon the aerial parts of theplant body
- Leaves are thick,entire, succulent andglossy. Some speciesare aphyllous (withoutleaves).
- Vivipary mode of seed germination is foundin halophytes

Anatomical adaptations

- Epidermal cells of stem is heavy cutinized,almost squarish and are filled with oil andtannins.
- 'Star' shaped sclereids and 'H' shaped heavy thickened spicules that provide mechanicalstrength to cortex are present in the stem.
- The leaves may be dorsiventral or isobilateral with salt secreting glands.

Physiological adaptations

- High osmotic pressure exists in someplants.
- Seeds germinate in the fruits of motherplant itself (Vivipary).

Out of three districts of Tamil Nadu (Nagapattinam, Thanjavur and Thiruvarur), Muthupet (Thiruvarur district) was less damaged by Gaja cyclone (November 2018) due to the presence of mangrove forest.

Dispersal of Fruits and Seeds

Both fruits and seeds possess attractive colour, odour, shape and taste needed for the dispersal by birds, mammals, reptiles, fish, ants and insects even earthworms. The seed consists of an embryo, stored food material and aprotective covering called seed coat. As seeds contain miniature but dormant future plants, their dispersal is an important criterion for distribution and establishment of plants over a wide geographical area. The dissemination of seeds and fruits to various distances from the parent plant is called seed and fruit dispersal. It takes place with the help of ecological factors such as wind, water and animals.

Seed dispersal is a regeneration process of plant populations and a common means of colonizing new areas to avoid seedling level competition and from natural enemies like herbivores, frugivores and pathogens.

Fruit maturation and seed dispersal is influenced by many ecologically favourable conditions such as Season (Example: Summer), suitable environment, and seasonal availability of dispersal agents like birds, insects etc.

Seeds require agents for dispersal which are crucial in plant community dynamics in many ecosystems around the globe. They offer many benefits to communities such as food and nutrients, migration of seeds across habitats and helps spreading plant genetic diversity.

Dispersal by Wind (Anemochory)

The individual seeds or the whole fruit may be modified to help for the dispersal by wind. Wind dispersal of fruits and seeds is quite common in tall trees. The adaptation of the wind dispersal plants are

- **Minute seeds:** Seeds are minute, verysmall, light and with inflated covering.Example: Orchids.
- **Wings:** Seeds or whole fruits are flattened to form a wing. Examples: Maple, Gyrocarpus,Dipterocarpus and Terminalia
- **Feathery Appendages**: Seeds or fruits mayhave feathery appendages which greatlyincrease their buoyancy to disperse to highaltitudes. Examples: Vernonia and Asclepias.
- **Censor mechanisms:** The fruits of manyplants open in such a way that the seedscan escape only when the fruit is violentlyshaken by a strong wind. Examples:Aristolochia and Poppy.

Dispersal by Water (Hydrochory)

Dispersal of seeds and fruits by water usually occurs in those plants which grow in or near water bodies. Adaptation of hydrochory are

- Obconical receptacle with prominent airspaces. Example: Nelumbo.
- Presence of fibrous mesocarp and lightpericarp. Example: Coconut.
- Seeds are light, small, provided with arilwhich encloses air.Example: Nymphaea.
- The fruit may be inflated. Examples:Heritieralittoralis.
- Seeds by themselves would not float may becarried by water current. Example: Coconut.

Dispersal by Animals (Zoochory)

Birds and mammals, including human beings play an efficient and important role in the dispersal of fruit and seeds. They have the following devices.

i. Hooked fruit: The surface of the fruit or seedshave hooks,(Xanthium), barbs (Andropogon),spines (Aristida) by means of which they adhereto the body of animals or clothes of humanbeings and get dispersed.
ii. Sticky fruits and seeds:
    a. Some fruits have sticky glandular hairs bywhich they adhere to the fur of grazing animals.Example: Boerhaavia and Cleome.
    b. Some fruits have viscid layer which adhere tothe beak of the bird which eat them and whenthey rub them on to the branch of the tree, theydisperse and germinate. Example: Cordia andAlangium
iii. Fleshy fruits: Some fleshy fruits withconspicuous colours are dispersed by humanbeings to distant places after consumption.Example: Mango and Diplocyclos

Dispersal by Explosive Mechanism (Autochory)

Some fruits burst suddenly with a force enabling to throw seeds to a little distance away from the plant. Autochory shows the following adaptations.

- Mere touch of some plants causes theripened fruit to explode suddenly and seeds are thrown out with great force. Example:Impatiens (Balsam), Hura.
- Some fruits when they come in contact with water particularly after a shower of rain,burst suddenly with a noise and scatter theseeds.Examples: Ruellia and Crossandra.
- Certain long pods explode with a loudnoise like cracker, scattering the seeds inall directions. Example: Bauhinia vahlii(Camel's foot climber)
- As the fruit matures, tissues around seeds areconverted into a mucilaginous fluid, due towhich a high turgor pressure develops insidethe fruit which leads to the dispersal of seeds.
  Example: Ecballiumelatrium (Squirting cucumber) Gyrocarpus and Dipterocarpus.

Human aided seed dispersal

Seed Ball: Seed ball is an ancient Japanese technique of encasing seeds in a mixture of clay and soil humus (also in cow dung) and scattering them on to suitable ground, not planting of trees manually. This method is suitable for barren and degraded lands for tree regeneration and vegetation before monsoon period where the suitable dispersal agents become rare.

Advantages of seed dispersal:

- Seeds escape from mortality near theparent plants due to predation by animalsor getting diseases and also avoidingcompetition.
- Dispersal also gives a chance to occupyfavourable sites for growth.

- It is an important process in the movementof plant genes particularly this is the onlymethod available for self-fertilized flowersand maternally transmitted genes inoutcrossing plants.
- Seed dispersal by animals help inconservation of many species even inhuman altered ecosystems.
- Understanding of fruits and seed dispersalacts as a key for proper functioning andestablishment of many ecosystems fromdeserts to evergreen forests and also for themaintenance of biodiversity conservationand restoration of ecosystems.

PLANT ECOLOGY

UNIT - 7 - ECOSYSTEM

Have you seen lakes, ponds and pools in your surroundings? They are all called water bodies with many components in them. Can you list out the things which are found in water bodies? Mud, nutrients, clay, dissolved gases, planktons, microorganisms, plants like algae, Hydrilla, Nelumbo, Nymphaea and animals like snake, small fish, large fish, frog, tortoise and crane are the components in the water bodies which are all together form an ecosystem.

Further, we all know that plants and animals are prominent living components in the environment. They interact with nonliving components such as air, water, soil, sunlight, etc. For example, you have studied in class XI, one of the life processes, photosynthesis which utilize sunlight , water, carbon-dioxide, nutrients from the soil and release oxygen to the atmosphere. From this, we understand that the exchange of materials takes place between living and non-living components.

Likewise, you can study the structure, function and types of ecosystem in this chapter. The term 'ecosystem' was proposed by A.G. Tansley (1935), who defined it as 'the system resulting from the integration of all the living and non-living factors of the environment'. Whereas, Odum (1962) defined ecosystem 'as the structural and functional unit of ecology'.

Parallel terms for ecosystem coined by various ecologists
- Biocoenosis – Karl Mobius
- Microcosm – S.A. Forbes
- Geobiocoenosis – V. V. Dokuchaev, G.F. Morozov
- Holocoen - Friederichs
- Biosystem – Thienemann
- Bioenert body – Vernadsky

Structure of ecosystem

Ecosystem comprises of two major components. They are:

i. Abiotic (non-living) components: It includes climatic factors (air, water, sunlight, rainfall, temperature and humidity), edaphic factors (soil air, soil water and pH of soil),topography (latitude, altitude), organic components (carbohydrates, proteins, lipids and humic substances) and inorganic substances (C, H, O, N and P). Abiotic components play vital role in any ecosystem and hence the total inorganic substances present in any ecosystem at a given time is called standing quality (or) standing state.

ii. Biotic (living) components: It includes all living organisms like plants, animals, fungi and bacteria. They form the trophic structures of any ecosystem. On the basis of nutritional relationships, trophic levels of an ecosystem has two components.

(1) Autotrophic components: Autotrophs are organisms which can manufacture the organic compounds from simple inorganic components through a process called photosynthesis. In most of the ecosystems, green plants are the autotrophs and are also called producers.

(2) Heterotrophic components: Those organisms which consume the producers are called consumers and can be recognized into macro and micro consumers. Macroconsumers refer to herbivores, carnivores and omnivores (primary, secondary and tertiary consumers). Microconsumers are called decomposers. Decomposers are organisms that decompose the dead plants and animals to release organic and inorganic nutrients into the environment which are again reused by plants. Example: Bacteria, Actinomycetes and Fungi.

The amount of living materials present in a population at any given time is known as standing crop, which may be expressed in terms of number or biomass per unit area. Biomass can be measured as fresh weight or dry weight or carbon weight of organisms. Biotic components are essential to construct the food chain, food web and ecological pyramids.

Functions of ecosystem

The function of ecosystem include to energy creation, sharing of energy and cycling of materials between the living and non-living component of an ecosystem.

Before studying the productivity in any ecosystem, We should understand the essential role of sunlight used by producers of the first trophic level. The quantity of sunlight is directly proportional to the production of energy by plants.

Photosynthetically Active Radiation (PAR)

The amount of light available for photosynthesis of plants is called Photosynthetically Active Radiation (PAR) which is between the range of 400-700 nm wave length. It is essential for photosynthesis and plant growth. PAR is not always constant because of clouds, tree shades, air, dust particles, seasons, latitudes and length of the daylight availability.

Generally plants absorb more blue and red light for efficient photosynthesis.

Of the total sunlight, 34 percent that reaching the atmosphere is reflected back into the atmosphere, moreover 10% is held by ozone, water vapours and atmospheric gases and the remaining 56% reaches the earth's surface. Out of this 56%, only 2 –

10% of the solar energy is used by green plants for photosynthesis while the remaining portion is dissipated as heat.

PAR is generally reported as millimoles / square meter / second by using silicon photovoltic detectors which detect only 400 – 700 nm wavelength of light. PAR values range from 0 to 3000 millimoles /square meter / second. At night PAR is zero and during midday in the summer, PAR often reaches 2000 – 3000 millimoles /square meter/second.

Types of Carbon

Green carbon – carbon stored in the biosphere (by the process of photosynthesis).
Grey carbon – carbon stored in fossil fuel (coal, oil and biogas deposits in the lithosphere).

Blue carbon – carbon stored in the atmosphere and oceans.

Brown carbon – carbon stored in industrialized forests (wood used in making commercial articles)

Black carbon – carbon emitted from gas, diesel engine and coal fired power plants.

Productivity of an ecosystem

The rate of biomass production per unit area in a unit time is called productivity. It can be expressed in terms of gm /m2/year or Kcal/m2/ year. It is classified as given bellow.

1. Primary productivity
2. Secondary productivity
3. Community productivity

1. Primary productivity:

The chemical energy or organic matter generated by autotrophs during the process of photosynthesis and chemosynthesis is called primary productivity. It is the source of energy for all organisms, from bacteria to human.

a. Gross Primary Productivity (GPP)

The total amount of food energy or organic matter or biomass produced in an ecosystem by autotrophs through the process of photosynthesis is called gross primary productivity

b. Net Primary Productivity (NPP)

The proportion of energy which remains after respiration loss in the plant is called net primary productivity. It is also called as apparent photosynthesis. Thus the difference between GPP and respiration is known as NPP.

NPP = GPP – Respiration

NPP of whole biosphere is estimated to be about 170 billion tons (dry weight) per year. Out of which NPP of oceanic producers is only 55 billion tons per year in unit time.

2. Secondary productivity

The amount of energy stored in the tissues of heterotrophs or consumers is called secondary productivity.

a. Gross secondary productivity

It is equivalent to the total amount of plant material is ingested by the herbivores minus the materials lost as faeces.

b. Net secondary productivity

Storage of energy or biomass by consumers per unit area per unit time, after respiratory loss is called net secondary productivity.

3. Community productivity

The rate of net synthesis of organic matter (biomass) by a group of plants per unit area per unit time is known as community productivity.

Factors affecting primary productivity

Primary productivity depends upon the plant species of an area, their photosynthetic capacity, availability of nutrients, solar radiation, precipitation, soil type, topographic factors (altitude, latitude, direction), and other environmental factors. It varies in different types of ecosystems.

Productivity of different Ecosystems

The primary productivity of an ecosystem is not determined by size and number of population, but by the rate of total fixation of radiant energy.

Generally, the average world net primary productivities of open ocean and tropical rain forest are the maximum among aquatic and terrestrial ecosystems respectively.

The following graph represents net primary productivity of various ecosystems.

Concept of trophic level in an ecosystem

(Greek word ' trophic' = to food or feeding)

A trophic level refers to the position of an organism in the food chain. The number of trophic levels is equal to the number of steps in the food chain. The green plants (producers) occupying the first trophic level (T_1) are called producers. The energy produced by the producers is utilized by the plant eaters (herbivores) they are called primary consumers and occupies the second trophic level (T_2).

Herbivores are eaten by carnivores, which occupy the third trophic level (T3). They are also called secondary consumers or primary carnivores. Carnivores are eaten by the other carnivores, which occupy the fourth trophic level (T4). They are called the tertiary consumers or secondarycarnivores. Some organisms which eat both plants and animals are called as omnivores (Crow). Such organisms may occupy more than one trophic level in the food chain.

Energy flow

The transfer of energy in an ecosystem between trophic levels can be termed as energy flow. It is the key function in an ecosystem. Part of the energy obtained from the sun by producer is transferred to consumers and decomposers through the each trophic level, while some amount of energy is dissipated in the form of heat. Energy flow is always unidirectional in an ecosystem.

Laws of thermodynamics

The storage and loss of energy in an ecosystem is based on two basic laws of thermo-dynamics.

i. First law of thermodynamics

It states that energy can be transmitted from one system to another in various forms. Energy cannot be destroyed or created. But it can be transformed from one form to another. As a result, the quantity of energy present in the universe is constant.

Example:

In photosynthesis, the product of starch (chemical energy) is formed by the combination of reactants (chlorophyll, H2O, CO2). The energy stored in starch is acquired from the external sources (light energy) and so there isno gain or loss in total energy. Here light energy is converted into chemical energy.

$$6\,CO_2 + 6\,H_20 \xrightarrow[\text{Chlorophyll}]{\text{light}} C_6H_{12}0_6 + 6\,O_2$$

Light energy ⟶ chemical energy

ii.Second law of thermodynamics

It states that energy transformation results in the reduction of the free energy of the system. Usually energy transformation cannot be 100% efficient. As energy is transferred from one organism to another in the form of food, a portion of it is stored as energy in living tissue, whereas a large part of energy is dissipated as heat through respiration. The transfer of energy is irreversible natural process. Example: Ten percent law

Ten percent law

This law was proposed by Lindeman (1942). It states that during transfer of food energy from one trophic level to other, only about 10% stored at every level and rest of them (90%) is lost in respiration, decomposition and in the form of heat. Hence, the law is called ten percent law.

Example: It is shown that of the 00 Jo les f Sola energy rapped by producers. 100 Joules f energystored chemical energy through photosynthesis. The remaining 900 Joules could be lost in the environment. In the next trophic level herbivores, which f ed on producers get only 10 Joules f energy and the remaining90 Joules is lost in the environment. Likewise, in the next trophic level, carnivores, which eatherbivores store only 1 Joule of energy and the remaining 9 Joules is dissipated. Finally, the carnivores are eaten by tertiary consumers which store only 0.1 Joule of energy and the remaining 0.9 Joule is lost in the environment. Thus, at the successive trophic level, only ten percent energy is stored.

Food chain

The movement of energy from producers upto top carnivores is known as food chain, i.e., in any food chain, energy flows from producers to primary consumers, then from primary consumers to secondary consumers, and finally secondary consumers to tertiary consumers. Hence, it shows linear network links. Generally, there are two types of food chain, (1) Grazing food chain and (2) Detritus food chain.

1. Grazing food chain

Main source of energy for the grazing food chain is the Sun. It begins with the first link, producers (plants). The second link in the food chain is primary consumers (mouse) which get their food from producers. The third link in the food chain is secondary consumers (snake) which get their food from primary consumers. Fourth

link in the food chain is tertiary consumers (eagle) which get their food from secondary consumers.

2. Detritus food chain:

This type of food chain begins with dead organic matter which is an important source of energy. A large amount of organic matter is derived from the dead plants, animals and their excreta. This type of food chain is present in all ecosystems.

The transfer of energy from the dead organic matter, is transferred through a series oforganisms called detritus consumers (detritivores)- small carnivores - large (top) carnivores with repeated eating and being eaten respectively. This is called the detritus food chain.

Food Web

The inter-locking pattern of a number of food chain form a web like arrangement called food web. It is the basic unit of an ecosystem, to maintain its stability in nature. It is called homeostasis.

Example: In a grazing food chain of a grass land, in the absence of a rabbit, a mouse may also eat food grains. The mouse in turn may be eaten directly by a hawk or by a snake and the snake may be directly eaten by hawks.

Hence, this interlocking pattern of food chains is the food web and the species of an ecosystem may remain balanced to each other by some sort of natural check.

Significance of food web

- Food web is constructed to describe species interaction called direct interaction.
- It can be used to illustrate indirect interactions among different species.
- It can be used to study bottom-up or top- down control of community structure.
- It can be used to reveal different patterns of energy transfer in terrestrial and aquatic ecosystems.

Ecological pyramids

Graphic representation of the trophic structure and function at successive trophic levels of an ecosystem is called ecological pyramids. The concept of ecological pyramids was introduced by Charles Elton (1927). Thus they are also called as Eltonian pyramids.

There are three types: (1) pyramid of number (2) pyramid of biomass (3) pyramid of energy.

1. Pyramid of number

A graphical representation of the number of organisms present at each successive trophic level in an ecosystem is called pyramids of number. There are three different shapes of pyramids upright, spindle and inverted.

There is a gradual decrease in the number of organisms in each trophic level from producers to primary consumers and then to secondary consumers, and finally to tertiary consumers. Therefore, pyramids of number in grassland and pond ecosystem are always upright.

In a forest ecosystem the pyramid of number is somewhat different in shape, it is because the base (T1) of the pyramid occupies large sized trees (Producer) which are lesser in number. Herbivores (T2) (Fruit eating birds, elephant, deer) occupying second trophic level, are more in number than the producers. In final trophic level (T4), tertiary consumers (lion) are lesser in number than the secondary consumer (T3) (fox and snake). Therefore, the pyramid of number in forest ecosystem looks spindle shaped.

The pyramid of number in a parasite ecosystem is always inverted, because itstarts with a single tree. Therefore there is gradual increase in the number of organisms in successive tropic levels from producer to tertiary consumers.

2. Pyramid of biomass

A graphical representation of the amount of organic material (biomass) present at each successive trophic level in an ecosystem is called pyramid of biomass. In grassland and forest ecosystems, there is a gradual decrease in biomass of organisms at successive trophic levels from producers to top carnivores (Tertiary consumer). Therefore, these two ecosystems show pyramids as upright pyramids of biomass. However, in pond ecosystem, the bottom of the pyramid is occupied by the producers, which comprise very small organisms possessing the least biomass and so, the value gradually increases towards the tip of the pyramid. Therefore, the pyramid of biomass is always inverted in shape.

3. Pyramid of energy

A graphical representation of energy flow at each successive trophic level in an ecosystem is called pyramids of energy. The bottom of the pyramid of energy is occupied by the producers. There is a gradual decrease in energy transfer at successive tropic levels from producers to the upper levels. Therefore, the pyramid of energy is always upright.

Decomposition:

Decomposition is a process in which the detritus (dead plants, animals and their excreta) are breakdown in to simple organic matter by the decomposers. It is an essential process for recycling and balancing the nutrient pool in an ecosystem.

Nature of decomposition

The process of decomposition varies based on the nature of the organic compounds, i.e., some of the compounds like carbohydrate, fatand protein are decomposed rapidly than the cellulose, lignin, chitin, hair and bone.

Mechanism of decomposition

Decomposition is a step wise process of degradation mediated by enzymatic reactions. Detritus acts as a raw material for decomposition. It occurs in the following steps.

a. Fragmentation - The breaking down of detritus into smaller particles by detritivores like bacteria, fungi and earth worm is known as fragmentation. These detritivores secrete certain substances to enhance the fragmentation process and increase the surface area of detritus particles.
b. Catabolism - The decomposers produce some extracellular enzymes in their surroundings to break down complex organic and inorganic compounds in to simpler ones. This is called catabolism
c. Leaching or Eluviation - The movement of decomposed, water soluble organic and inorganic compounds from the surface to the lower layer of soil or the carrying awayof the same by water is called leaching or eluviation.
d. Humification - It is a process by which simplified detritus is changed into dark coloured amorphous substance called humus. It is highly resistant to microbial action, therefore decomposition is very slow. It is the reservoir of nutrients.
e. Mineralisation - Some microbes are involved in the release of inorganic nutrients from the humus of the soil, such process is called mineralisation.

Factors affecting decomposition

Decomposition is affected by climatic factors like temperature, soil moisture, soil pH,oxygen and also the chemical quality of detritus.

Biogeochemical cycle (Nutrient cycle)

Exchange of nutrients between organisms and their environment is one of the essential aspects of an ecosystem. All organisms require nutrients for their growth, development, maintenance and reproduction. Circulation of nutrients within the

ecosystem or biosphere is known as biogeochemical cycles and also called as 'cycling of materials.' There are two basic types,

1. Gaseous cycle – It includes atmospheric Oxygen, Carbon and Nitrogen cycles.
2. Sedimentary cycle – It includes the cycles of Phosphorus, Sulphur and Calcium –Which are present as sediments of earth.

Many of the cycles mentioned above are studied by you in previous classes. Therefore, in this chapter, only the carbon and phosphorous cycles are explained.

Carbon cycle

The circulation of carbon between organisms and environment is known as the carbon cycle. Carbon is an inevitable part of all biomolecules and is substantially impacted by the change in global climate. Cycling of carbon between organisms and atmosphere is a consequence of two reciprocal processes of photosynthesis and respiration. The releasing of carbon in the atmosphere increases due to burning of fossil fuels, deforestation, forest fire, volcanic eruption and decomposition of dead organic matters.

Phosphorus cycle

It is a type of sedimentary cycle. Already we know that phosphorus is found in the biomolecules like DNA, RNA, ATP, NADP and phospholipid molecules of living organisms. Phosphorus is not abundant in the biosphere, whereas a bulk quantity of phosphorus is present in rock deposits, marine sediments and guano. It is released from these deposits by weatheringprocess. After that, it circulates in lithosphere as well as hydrosphere. The producers absorb phosphorus in the form of phosphate ions, and then it is transferred to each trophic level of food chain through food. Again death of the organisms and degradation by the action of decomposers, the phosphorus is released back into the lithosphere and hydrosphere to maintain phosphorus cycle.

Types of ecosystem

Biosphere consists of different types of ecosystems, which are as follows:

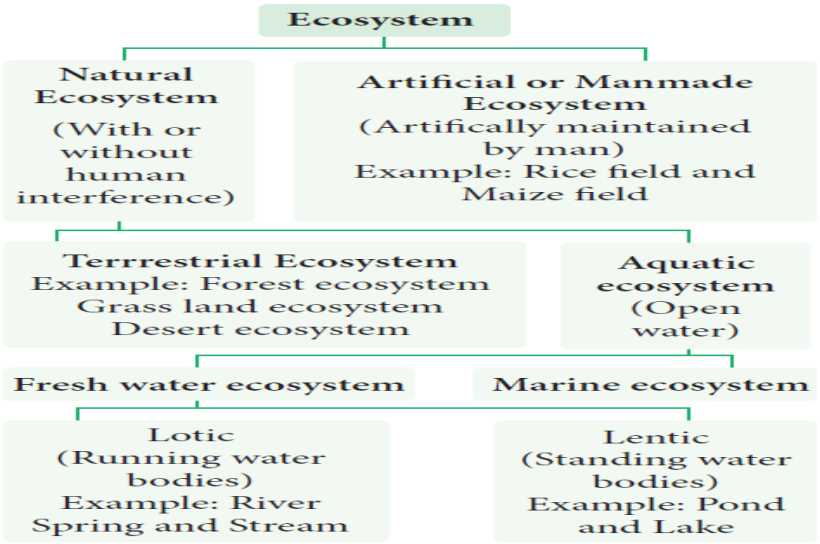


Figure 7.14: Types of Ecosystem

Though there are many types of ecosystems as charted above. Only the pond ecosystem is detailed below.

It is a classical example for natural, aquatic, freshwater, lentic type of ecosystem. It helps us to understand the structure and function of an ecosystem. When rain water gathers in a shallow area, gradually over a period of time, different kinds of organisms (microbes, plants, animals) become part of this ecosystem. This pond ecosystem is a self sustaining and self regulatory fresh water ecosystem, which shows a complex interaction between the abiotic and biotic components in it.

Abiotic components

A pond ecosystem consists of dissolved inorganic (CO2, O2, Ca, N, Phosphate) and organic substances (amino acids and humic acid) formed from the dead organic matter. The function of pond ecosystem is regulated by few factors like the amount of light, temperature, pH value of water and other climatic conditions.

Biotic components

They constitute the producers, variety of consumers and decomposers (microorganisms).

a. Producers

A variety of phytoplanktons like Oscillatoria, Anabaena, Eudorina, Volvox and Diatoms. Filamentous algae such as Ulothrix, Spirogyra, Cladophora and Oedogonium; floating plants Azolla, Salvia, Pistia, Wolffia and Eichhornia; submerged plants Potamogeton and Phragmitis; rooted floating plants Nymphaea and Nelumbo; macrophytes like Typha and Ipomoea, constitute the major producers of a pond ecosystem.

b. Consumers

The animals represent the consumers of a pond ecosystem include zooplanktons like Paramoecium and Daphnia (primary consumers); benthos (bottom living animals) like mollusces and annelids; secondary consumers like water beetles and frogs; and tertiary consumers (carnivores) like duck , crane and some top carnivores which include large fish, hawk ,man, etc.

c. Decomposers

They are also called as microconsumers. They help to recycle the nutrients in the ecosystem. These are present in mud water and bottom of the ponds. Example: Bacteria and Fungi. Decomposers perform the process of decomposition in order to enrich the nutrients in the pond ecosystem. The cycling of nutrients between abiotic and biotic components is evident in the pond ecosystem, making itself self sufficient and self regulating.

Limnology It is the study of biological, chemical, physical and geological components of inland fresh water aquatic ecosystems (ponds, lakes, etc.).
Oceanography – It is the study of biological, chemical, physical and geological components of ocean.

Stratification of pond ecosystem

Based on the factors like distance from the shore, penetration of light, depth of water, types of plants and animals, there may be three zones, littoral, limnetic and profundal. The littoral zone, which is closest to the shore with shallow water region, allows easy penetration of light. It is warm and occupied by rooted plantspecies. The limnetic zone refers the open water of the pond with an effective penetration of light and domination of planktons. The deeper region of a pond below the limnetic zone is called profundal zone with no effective light penetration and predominance of heterotrophs. The bottom zone of a pond is termed benthic and is occupied by a community of organisms called benthos (usually decomposers).The primary productivity through photosynthesis of littoral and limnetic zone is more due to greater penetration of light than the profundal zone.

Ecosystem services (Benefits)

Ecosystem services are defined as the benefits that people derive from nature. Robert Constanza et al (1927) stated "Ecosystem services are the benefits provided to human, through the transformation of resources (or Environmental assets including land, water, vegetation and atmosphere) into a flow of essential goods and services".

Study on ecosystem services acts as an effective tool for gaining knowledge on ecosystem benefits and their sustained use. Without such knowledge gain, the fate of

any ecosystem will be at stake and the benefits they provide to us in future will become bleak.

Robert Constanza and his colleagues estimated the value of global ecosystem services based on various parameters. According to them in 1997, the average global value of ecosystems services estimated was US $ 33 trillion a year. The updated estimate for the total global ecosystem services in 2011 is US $ 125 trillion / year, indicating a four-fold increase in ecosystem services from 1997 to 2011.

Mangrove ecosystem services

- Offers habitat and act as nursery for aquatic plants and animals
- Provides medicine, fuel wood and timber.
- Act as bridge between sea and rivers by balancing sedimentation and soil erosion.
- Help to reduce water force during cyclones, tsunamis and high tide periods.
- Help in wind break, O2 production, carbon sequestration and prevents salt spray from waves.

The varieties of benefits obtained from the ecosystem are generally categorized into the following four types

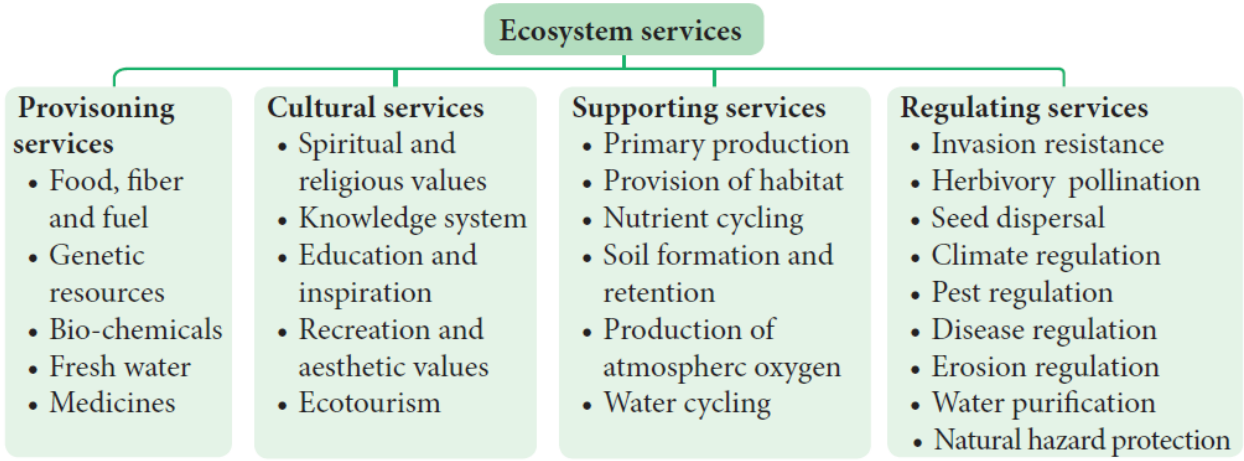


Figure 7.17: Types of Ecosystem services

How do anthropogenic activities affect ecosystem services?

Now, we all exploit the ecosystem more than that of our needs. The Millennium Ecosystem Assessment (2005) found that "over the past 50 years, humans have changed the ecosystem more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, fresh water, medicine, timber, fiber and fuel."

Generally the following human activities disturb or re-engineer an ecosystem every day.

- Habitat destruction
- Deforestation and over grazing
- Erosion of soils
- Introduction of non-native species
- Over harvesting of plant material
- Pollution of land, water and air
- Run off pesticides, fertilizers and animal wastes

Ecosystem resilience

Ecosystem is damaged by disturbances from fire, flood, predation, infection, drought, etc., removing a great amount of biomasss. However, ecosystem is endowed with the ability to resist the damage and recover quickly. This ability of ecosystem is called ecosystem resilience or ecosystem robustness.

How to protect the ecosystem?

It is a practice of protecting ecosystem at individual, organisational and governmental levels for the benefits of both nature and humans. Threats to ecosystems are many, like adverse human activities, global warming, pollution, etc. Hence, if we change our everyday life style, we can help to protect the planet and its ecosystem.

"If we fail to protect environment, we will fail to save posterity".

Therefore, we have to practice the following in our day today life:

- Buy and use only ecofriendly products and recycle them.
- Grow more trees
- Choose sustained farm products (vegetables, fruits, greens, etc.)
- Reduce the use of natural resources.
- Recycle the waste and reduce the amount of waste you produce.
- Reduce consumption of water and electricity.
- Reduce or eliminate the use of house-hold chemicals and pesticides.
- Maintain your cars and vehicles properly. (In order to reduce carbon emission)
- Create awareness and educate about ecosystem protection among your friends and family members and ask them to find out solution to minimise this problem.

Ecosystem Management

It is a process that integrates ecological, socio economic and institutional factors into a comprehensive strategy in order to sustain and enhance the quality of the ecosystem to meet current and future needs.

Ecosystem management emphasis on human role in judicious use of ecosystem and for sustained benefits through minimal human impacts on ecosystems. Environmental degradation and biodiversity loss will result in depletion of natural resources, ultimately affecting the existence of human

"By 2025, at least 3.5 billion people, nearly 50% of the world's population are projected to face water scarcity." – IUCN.
"Forests house approximately 50% of global bio-diversity and at least 300 million people are dependent on forest's goods and services to sustain their livelihood." – IUCN

Strategy of ecosystem management

- It is used to maintain biodiversity of ecosystems.
- It helps in indicating the damaged ecosystem (Some species indicate the health of the ecosystem: such species are called a flagship species).
- It is used to recognize the inevitability of ecosystem change and plan accordingly.
- It is one of the tools used for achieving sustainability of ecosystem through sustainable development programme (or projects).
- It is also helpful in identifying ecosystems which are in need of rehabilitation.
- It involves collaborative management with government agencies, local population, communities and NGO's.
- It is used to build the capacity of local institutions and community groups to assume responsibility for long term implementation of ecosystem management activities even after the completion of the project.

Urban ecosystem restoration model

AdayarPoonga is located in Chennai and covers an area around a total of 358 acres of Adayar creek and estuary, of which 58 acres were taken up for eco restoration under the auspices of Government of Tamil Nadu. It is maintained by Chennai Rivers Restoration Trust (CRRT).This was a dumping site previously.

Presently it has 6 species of mangroves, about 170 species of littoral and tropical dry evergreen forests (TDF) which have successfully established as a sustainable ecosystem. Restoration of plants species has brought other associated fauna such as butterflies, birds, reptiles, amphibians and other mammals of the ecosystem.

Currently AdayarPoonga functions as an environmental education Centre for school and college students and the public. The entire area stands as one of the best

examples for urban eco restoration in the state of Tamil Nadu.

Plant Succession

We very often see that forests and lands in our areas are drastically affected by natural calamities (Flood, earthquake) and anthropogenic activities (Fire, over grazing, cutting of trees). Due to these reasons all plants of an area are destroyed and the areas become nude. When we observe this area, over a period of a time we can see that it will be gradually covered by plant community again and become fertile. Such successive replacement of one type of plant community by the other of the same area/ place is known as plant succession. The first invaded plants in a barren area are called pioneers. On the other hand, a series of transitional developments of plant communities one after another in a given area are called seral communities. At the end a final stage and a final plant community gets established which are called as climax and climax community respectively.

Causes of Succession

Ever since the onset of origin of life, organic evolution and ecological succession are taking place parallelly. Ecological succession is a complex process. There are three types of causes for any ecological succession. They are

a. Initiating causes - Activity of abiotic (light, temperature, water, fire, soil erosion and wind) and biotic factors (competition among organisms) leads to formation of a barren area or destruction of the existing community of an area, initiating primary or secondary succession respectively.
b. Continuing causes - The processes of migration, aggregation, competition, reaction etc, are the continuing causes which lead to change the plant communities and nature of the soil in an area.
c. Stabilizing causes - The stabilization of the plant community in an area is primarly controlled by climatic factors rather than other factors.

Characteristics of ecological succession

- It is a systematic process which causes changes in specific structure of plant community.
- It is resultant of changes of abiotic and biotic factors.
- It transforms unstable community into a stable community.
- Gradual progression in species diversity, total biomass, niche specialisation, and humus content of soil takes place.
- It progresses from simple food chain to complex food web.
- It modifies the lower and simple life form to the higher life forms.
- It creates inter-dependence of plants and animals.

Types of succession

The various types of succession have been classified in different ways on the basis of different aspects. These are as follows:

1. Primary succession - The development of plant community in a barren area where no community existed before is called primary succession. The plants which colonize first in a barren area is called pioneer species or primary community or primary colonies. Generally, Primary succession takes a very long time for the occurrence in any region.
   Example: Microbes, Lichen, Mosses.

2. Secondary succession - The development of a plant community in an area where an already developed community has been destroyed by some natural disturbance (Fire, flood, human activity) is known as secondary succession. Generally, This succession takes less time than the time taken for primary succession.
   Example: The forest destroyed by fire and excessive lumbering may be re-occupied by herbs over period of times.

	Primary succession	Secondary Succession
1	Developing in an barren area	Developing in disturbed area
2.	Initiated due to a biological or any other external factors	Starts due to external factors only
3.	No Soil, while primary succession starts	It starts where soil covers already present
4.	Pioneer species come from outside environment	Pioneer species develop from existing environment
5.	It takes more time to complete	It takes comparatively less time to complete.

3. Autogenic succession

Autogenic succession occurs as a result of biotic factors. The vegetation reacts with its environment and modifies its own environment causing its own replacement by new communities. This is known as autogenic succession.

Example: In forest ecosystem, the larger trees produce broader leaves providing shade to theforest floor area. It affects the shrubs and herbs which require more light (heliophytes) but supports the shade tolerant species (sciophytes) to grow well.

4. Allogenic succession

Allogeneic succession occurs as a result of abiotic factors. The replacement of existing community is caused by other external factors (soil erosion, leaching, etc.,) and not by existing organisms.

Example: In a forest ecosystem soil erosion and leaching alter the nutrient value of the soil leading to the change of vegetation in that area.

5. Autotrophic succession

If the autotrophic organisms like green plants are dominant during the early stages of succession it is called autotrophic succession, this occurs in the habitat which is rich in inorganic substances. Since, green plants dominate in the beginning of this succession, there is a gradual increase in organic matter and subsequently the energy flow in the ecosystem.

6. Heterotrophic succession

If heterotrophic organisms like bacteria, fungi, actinomycetes, and animals are dominant during the early stages of succession it is called heterotrophic succession. Such a succession takes place in organic habitats. Since heterotrophs dominate in the beginning of such succession, there will be a gradual decrease in the energy content.

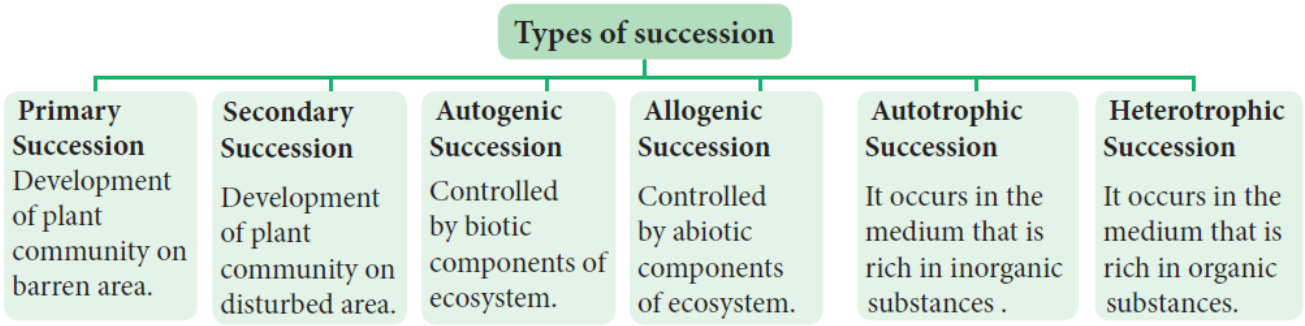


Figure 7.19: Types of succession

Process of succession

There are a number of sequential processes in primary autotrophic succession. They are (1) Nudation, (2) Invasion (migration) (3) Ecesis, (4) Aggregation, (5) Competition, (6) Reaction (7) Stabilization (climax).

1. Nudation - This is the development of a barren area without any form of life. The barren area may be developed due to topographic (soil erosion, wind action), climatic (hails, storm, fire), and biotic (human activities, epidemics, etc.,) factors.

2. Invasion - If species invade or reach a barren area from any other area it is called invasion. When the seeds, spores or other propagules of plant species reach the barren area, by air, water and various other agent, it is known as migration.
3. Ecesis (Establishment) - After reaching a new area (invasion), the successful establishment of the species, as a result of adjustment with the conditions prevailing in the area, is known as ecesis. If the establishment is complete, the plant will be able to reproduce sexually in that particular area.
4. Aggregation - The successful establishment of species, as a result of reproduction and increase in population of the species than the earlier stage is called aggregation.
5. Competition - It refers to the aggregation of a particular species in an area which leads to inter specific and intraspecific competition among the individuals for water, nutrient, radiant energy, CO2, O2 and space, etc.
6. Reaction - The species occupying a habitat gradually modify the environmental condition, where the existing species community is displaced or replaced by another. This is called reaction. The community which is replaced by another community is called seral community.
7. Stabilization (Climax stage) - The final establishment of plant community is called stabilization. This establishment of a plant community which maintains itself in equilibrium with climax of the area and not replaced by others is known as climax community and the stage is climax stage.

Classification of plant succession

Detailed study of Hydrosere and Lithosere are discussed below:

The succession in a freshwater ecosystem is also referred to as hydrosere. Succession in a pond, begins with colonization of the pioneers like phytoplankton and finally ends with the formation of climax community like forest stage. It includes the following stages Fig 7.21.

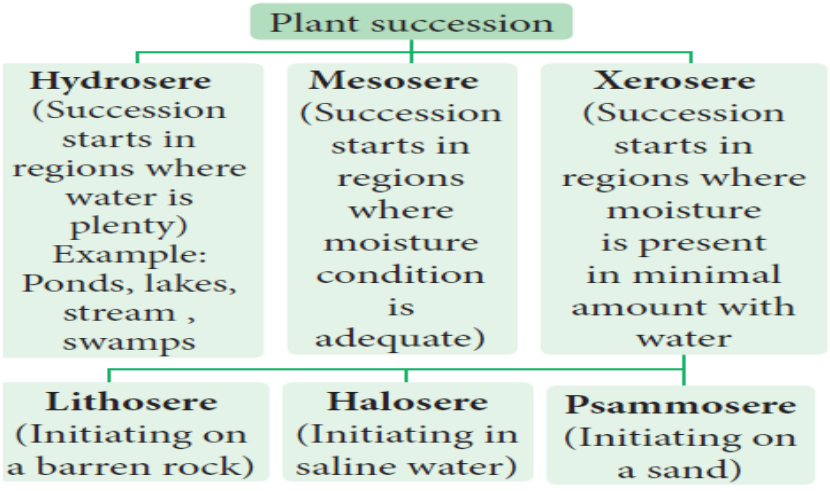


Figure 7.20: Classification of plant succession

1. Phytoplankton stage - It is the first stage of succession consisting of the pioneer community like blue green algae, green algae, diatoms, bacteria, etc., The colonization of these organisms enrich the amount of organic matter and nutrients of pond due to their life activities and death. This favors the development of the next seral stages.

2. Submerged plant stage - As the result of death and decomposition of planktons, silt brought from land by rain water, lead to a loose mud formation at the bottom of the pond.

3. Hence, the rooted submerged hydrophytes begin to appear on the new substratum. Example: Chara, Utricularia, Vallisneria and Hydrilla etc. The death and decay of these plants will build up the substratum of pond to become shallow. Therefore, this habitat now replaces another group of plants which are of floating type.

4. Submerged free floating stage - During this stage, the depth of the pond will become almost 2-5 feet. Hence, the rooted hydrophytic plants and with floating large leaves start colonising the pond. Example: Rooted floating plants like Nelumbo, Nymphaea and Trapa. Some free floating species like Azolla, Lemna, Wolffia and Pistia are also present in this stage. By death and decomposition of these plants, further the pond becomes more shallow. Due to this reason, floating plant species is gradually replaced by another species which makes new seral stage.

5. Reed-swamp stage - It is also called an amphibious stage. During this stage, rooted floating plants are replaced by plants which can live successfully in aquatic as well as aerial environment. Example: Typha, Phragmites, Sagittaria and Scirpus etc. At the end of this stage, water level is very much reduced, making it unsuitable for the continuous growth of amphibious plants.

6. Marsh meadow stage - When the pond becomes swallowed due to decreasing water level, species of Cyperaceae and Poaceae such as Carex, Juncus, Cyperus and Eleocharis colonise the area. They form a mat-like vegetation with the help of their much branched root system. This leads to an absorption and loss of large quantity of water. At the end of this stage, the soil becomes dry and the marshy vegetation disappears gradually and leads to shurb stage.

7. Shrub stage - As the disappearance of marshy vegetation continues, soil becomes dry. Hence, these areas are now invadedby terrestrial plants like shrubs (Salix and Cornus) and trees (Populus and Alnus). These plants absorb large quantity of water and make the habitat dry. Further, the accumulation of humus with a rich flora of microorganisms produce minerals in the soil, ultimately favouring the arrival of new tree species in the area.

8. Forest stage - It is the climax community of hydrosere. A variety of trees invade the area and develop any one of the diverse type of vegetation. Example:Temperate mixed forest (Ulmus,Acer and Quercus), Tropical rain forest (Artocarpus and Cinnamomum) and Tropical deciduous forest (Bamboo and Tectona).

In the 7 stages of hydrosere succession, stage1 is occupied by pioneer community, while the stage 7 is occupied by the climax community. The stages 2 to 6 are occupied by seral communities.

Lithosere

Lithosere is a type of xerosere initiating on a barren rock surface. The barren rock is devoid of water and organic matter. A barren rock surface gets mineral deposits due to weathering. This results in the colonization of pioneer organisms like crustose lichens. Through a series of successive seral stages, forest stage (Climax community) is achieved finally.

1. Crustose lichen stage - The pioneers like crustose lichens (Rhizocarpon and Lecanora) secrete some acids which enhance the weathering of rock. Due to this continuous process, small particles of rocks are formed, which together with decaying lichen make the first thin layer of soil on rock surface. However, this process is very slow. At the end, this habitats become less fit for existing plants and is gradually replaced by another type of lichens called foliose lichen.
2. Foliose lichen stage - Gradually crustose lichens are replaced by foliose lichen likeParmelia and Dermatocarpon etc. These plants have leaf like structures. They also secrete some acids which further loosen the rocks into small soil particles. This process enhances water retaining capacity of the habitat and causes further accumulation of soil particles and humus. Gradual changes make the area less favourable for existing foliose lichen.
3. Moss stage - When the habitat is changed, the existing foliose lichen starts disappearing and favours the growth of some xerophytic moss like Polytrichum, Tortula and Grimmia. The luxurious growth of moss competes with lichens. Due to the death and decay of mosses, further addition of humus and moisture to the habitat takes place. Therefore, the next seral community tries to replace the moss community.

4. Herb stage - With the gradual disappearance of moss stage, herbaceous plant communities like Aristida, Festuca and Poa, etc., invade the habitat. The extensive growth of these herbs alter the habitat. The decaying leaves, stems, root and other parts of these plants get deposited on the soil surface in the form of humus. It further increases the water holding capacity of soil. These conditions become more suitable for shrubs.

5. Shrub stage - The habitat change results in the invasion of shrubs like Rhus, Zizyphus, Capparis and dominated by herbaceous plants. The death and decaying of shrubs further enrich the habitat with soil and humus. Therefore, the shrubs are replaced by trees which constitute the climax community.
6. Forest stage - The trees capable of growing in xerophytic condition try to invade the area which was occupied previously by shrubs. Further increasing the humus content of the soil favours the arrival of more trees and vegetation finally become mesophytes. As the trees are deeply rooted and much branched, they absorb more quantity of water and nutrients. After a long interval, a complete harmony is established among the plant communities. The climax stage remains unchanged unless some major environmental changes disturb it

Of the 6 stages of lithosere succession, stage 1 is occupied by pioneer community and the stage 6 is occupied by climax community. The stages 2 to 5 are occupied by seral communities. Seral stages occurring on the same rock surfaces.

Significance of Plant Succession

- Succession is a dynamic process. Hence an ecologist can access and study the seral stages of a plant community found in a particular area.
- The knowledge of ecological succession helps to understand the controlled growth of one or more species in a forest.
- Utilizing the knowledge of succession, even dams can be protected by preventing siltation.
- It gives information about the techniques to be used during reforestation and afforestation.
- It helps in the maintenance of pastures.
- Plant succession helps to maintain species diversity in an ecosystem.
- Patterns of diversity during succession are influenced by resource availability and disturbance by various factors.
- Primary succession involves the colonization of habitat of an area devoid of life.
- Secondary succession involves the reestablishment of a plant community in disturbed area or habitat.
- Forests and vegetation that we come across all over the world are the result of plant succession.

Vegetation

Vegetation refers to the plant cover of an area. Geographically, India is a tropical country and also has strong monsoon climate and differs from other tropical regions of the World. India has four major climatic regions such as wet zone, intermediate zone, dry zone and arid zone, These regions are characterized by different types of natural vegetation. Nature of vegetation is also determined by several factors like altitude, types of plants, animals, climate, soil type, etc. Vegetation in Indian sub-

continent is influenced by biotic factors and the existing human culture for a long time. The influence of man on plant formation and distribution is called anthropogenic effect on vegetation.

Tamil Nadu has a rich biodiversity right from the Gulf of Mannar to Western Ghats. Tamil Nadu shares the Western Ghats with states of Kerala, Karnataka, Goa, Maharashtra, Gujarat while Eastern Ghats is shared with the State of Andhra Pradesh. Of the 10 geographic zones in India, Coramandel (or) East Coast and Western Ghats are from Tamil Nadu.

Vegetation types of India and Tamil Nadu

Vegetation of India and Tamil Nadu consists of variety of plant communities and also possesses rich bio-diversity. It is classified in to the following four types, Which are explained with reference to their unique characteristics and distribution in India and Tamil Nadu:

Forest vegetation
Grassland vegetation
Riparian vegetation
Aquatic and semi aquatic vegetation

Forest Vegetation

Champion and Seth (1968) recognized a total of 16 forest types in India, Whereas 9 types of them in Tamil Nadu.

I) Moist Tropical Forests

It is in the warmer plains. It is characterised by very dense, multi-storeyed diverse trees, shrubs, lianas and scrub jungles. These areas experience a high rainfall and dry climate. These are further classified into the following types on the basis of wetness.

1. Tropical wet evergreen forests

This type is found at an altitude of nearly 1500 m on the slopes of hills and mountains.These are also called tropical rain forests or tropical wet evergreen forests, where annual rainfall is more than 250 cm.. Vegetation consists of luxuriantly growing huge trees of more than 45 m in height, shrubs, lianas and abundant epiphytes. The common plants are Dipterocarpus, Artocarpus, Mangifera, Emblica and Ixora. These forests occur in Andaman and Nicobar Islands, Western Coasts, Anamalai hills and Assam. This type is also found in western ghats of Thirunelveli, Kanyakumari, Anamalai Hills of Tamil Nadu

2. Tropical semi-evergreen forests

This type occurs on the slopes of hills and mountain usually up to 1000 m altitude.The annual rainfall in these forests is between 200 to 250 cm. Vegetation consists of luxuriantly growing evergreen species of giant trees and shrubs. The common tree species are Terminalia, Bambusa, Ixora, Artocarpus, Michelia, Eugenia, and Shorea. Orchids, ferns, some grasses,and herbs are also dominant. These forest are found in Western Coasts, Eastern Orissa and Upper Assam. This type is also present in Coimbatore, Thirunvelveli and Kanyakumar District of Tamil Nadu

3. Tropical moist deciduous forests

The annual rainfall of these forests is 100 to 200 cm with short dry periods. These are spread over an extensive part of the country. Many of the plants shed their leaves in hot summer. Some are ever green and semi-evergreen. The common plant species are Terminalia, Grewia, Adina, Melia, Albizzia, Dalbergia and Shorea. The most dominant plants are Tectona and Sal. These are found in Kerala, Karnataka, South Madhya Pradesh, northern parts of Uttar Pradesh, Bihar, Bengal, Orissa and Assam. This type is also present in Kanyakumari, Theni, Gudalur, Dindigul, Madurai and Nilgiris of Tamil Nadu.

4. Littoral and swamp forests

These include beach forests, tidal forests, mangrove forests and fresh water swamp forests.

a. Beach forests

These are found all along the sea coasts and river deltas. These areas have sandy soil which consists of large amount of lime and salts but poor in nitrogen and other mineral nutrients. The rainfall varies from 75 cm to 500 cm with moderate temperature. The common tree species are Casuarina, Borassus, Phoenix, Pandanus ,Morinda and Thespesia with many twiners and climbers.

b. Tidal or mangrove forests

Tidal forests grow near the estuaries, swampy margins of islands and along sea coasts. The plants are halophytes characterized by the presence of stilt roots, pneumatophores and viviparous germinations of seed. The common plants are Rhizophora, Avicennia, and Sonneratia. These are found near sea coast,Gujarat, Ganges, delta regions of Mahanadhi, Godavari, Krishna, Sundarbans and Pulicat, Pichavaram, Ramanathapuram of Tamil Nadu.

c. Fresh water swamp forests

These forests grow in low lying land areas where rain or river water gets collected for some time. So the water table is closer to the earth surface. The common plants

are Salix, Acer, Ficus and all varieties of grasses and sedges. These forests are found in wetlands of Kanchipuram, Kanniyakumari of Tamil Nadu.

II. Dry Tropical Forests

These are classified into three types: Tropical dry deciduous forests, tropical thorn forests and tropical dry evergreen forests

5. Tropical dry deciduous forests

These forests are found at about 400 to 800 m MSL.These forests are found in the areas where annual rainfall is usually low, ranging between 70 and 100 cm. The largest forest area of the country is occupied by tropical dry deciduous forest. The dry season is long and most of the trees remain leafless during this season. The forest trees are not dense, and grow up to 10 to 15 m in height. The common plant species are Dalbergia, Diospyros, Terminalia, Acacia, Chloroxylon, Bauhinia and Zizyphus. Some common Climbers are Combretum, Hiptage: herbs like Abutilon, Achyranthes and Tribulus. These are found in Andhra Pradesh, Punjab, Uttar Pradesh, Bihar, Orissa, Madhya Pradesh and also found in all districts of Tamil Nadu at lower elevations.

6. Tropical thorn forests

These forests extend from plains upto 400 M . Occur in the areas where annual rainfall is between 20 and 70 cm. The dry season is hot and very long. The vegetation is of open type consisting of small trees (8 to 10 m length) and thorny or spiny shrubs with a stunted growth. The plants remain leafless for most of the year and many species have latex.. In rainy season, there is a luxuriant growth of ephemeral herbs and grass. The most common plant species are Acacia, Cassia, Calotropis, Albizzia, Zizyphus, Dichrostachys, Euphorbia, Capparis, and including unpalatable species. They are found in Karnataka, Andhra Pradesh, Maharashtra, South Punjab, most parts of Rajasthan and part of Gujarat and Thirunelveli in Tamil Nadu.

7. Tropical dry evergreen forests

This type of vegetation is found in areas where annual rainfall is in plenty but the dry season is comparatively longer. The trees are dense, evergreen, short and about 10 to 15 meter height. The common plant species are Manilkara ,Walsura, Diospyros and Memexylon These types of forests are found in the eastern parts of Tamil Nadu, East coat of Andhra pradesh. They are also found in all coastal districts in Tamil Nadu from Thiruvallur to Nagapatinum districts.

III. Montane Subtropical Forests

This type of vegetation occurs in the areas with fairly high rainfall but where the climate is cooler than the tropical and warmer than the temperate forests. They are

found in the altitude between 1000 m and 2000 m. The common plants are Eugenia, Syzygium and Toona are mostly evergreens. Many epiphytes including orchids and ferns are present. These are found in Nilgiri, Mahabaleswar, Assam and Manipur. In Eastern Ghats,it is found in the upper slopes and plateau of shervaroys, Kollimalai and Pachamalai of Tamil Nadu

These are further classified into

8. Sub-tropical broad leaved hill forests (Tamil Nadu,Kerala,Karnataka and Assam).

9. Sub-tropical pine forests (Punjab, U.P and a part of Sikkim)

10. Sub-tropical dry evergreen forests (Shivaliks and foot hills of western Himalayas).

IV. Montane Temperate Forests

This type of vegetation occurs where humidity and temperature are comparatively low. These forests are very dense with an extensive growth of grass and evergreen trees of 15 – 45 meters tall. The common plants are Artocarpus, Balanocarpus, Pterocarpus, Myristica and woody climbers besides ferns and epiphytes. It is also called mountain wet temperate forests. They are found in mountains of Himalayas. These are further classified into

11.Montane wet temperate forests.

12. Himalayan moist temperate forests.

13. Himalayan dry temperate forests.

In Tamil Nadu montane forest is mostlyconfined to moist and sheltered valleys, glens and hollows as in the Anamalis, Nilgiri and Palani hills tops at above 1000 m. They are known in Tamil as 'Sholas'. The common vegetation of sholas are Ilex, Syzygium, Michelia, Eurya and Rhododendron.

V Sub-Alpine Forests

14 Sub-Alpine Forests

This type of vegetation is found in the altitude ranging between 2900 m to 3500 m, where snow fall occurs for several weeks in a year with less than 65 cm annual rainfall. Hence, strong winds and below 00 C temperature prevail for greater part of the year. The common tree species are Abies, Pinus, Betula, Quercus, Salix, Rhododendron with plenty of epiphytic orchids ,mosses and lichens. They occur in

Himalayas from Ladakh in the West to Arunachal in the East Bengal, Uttar Pradesh, Assam, Jammu and Kashmir.

VI Alpine - Scrub

This type of vegetation is found in the Himalayas at an altitude ranging from 3600 m to 4900 m. The height of the trees decreases with increasing altitudes. The common plants are small sized plants such as Sedum, Primula, Saxifraga, Rhododendron ,Juniperus and with many types of lichens. These are further classified into

15.Moist alpine scrubs

16. Dry alpine scrubs.

2. Grass land vegetation

Grassland refer to the vegetation community predominated by graminoids (i.e. grass and grass like plants). These are found in the altitude ranging from 150 to 2000 m and above mean sea level. The major plant families of the plants are Poaceae, Cyperaceae, Fabaceae, Gentianaceae and Asteraceae are common in this type of vegetation. The grass land not only comprises plants but also serves as habitats to a variety of micro and macro fauna. Based on the range ofaltitude, grasslands are categorized into: low altitude grasslands and high altitude grasslands.

a. Low altitude grasslands

This type of grasslands are found at an altitude upto 1000 m. The common plant species are Halopyrum, Wild Saccharum, Arundinella, Heteropogon and Chrysopogon. These types of grasslands are spread over coastal areas, riverline and alluvial areas of Deccan plateau, Chota Nagpur plateau, Gangetic, Brahmaputra valley and Eastern Ghats.

In Tamil Nadu, these are found in the Eastern Ghats .These are scattered and intermixed with local forests. They are exposed to considerable biotic interference. Fire is common during dry months.

b. Higher altitude grasslands

This type of grasslands are found in altitude above 1000 m.The common plants species are Chrysopogon, Arundinella, Andropogon, Heteropogon, Cymbopogon, Imperata, Festuca, and Agrostis.. It is spread over the southern slopes of Himalayas, sub-Himalayan ranges, Nagaland, H i m a c h a l Pradesh and Western ghats.

In Tamil Nadu ,these grasslands are found in higher regions of western ghats and are found between the sholas forest patches that occur in the depressions and

furrows created by water courses flowing in these rolling downs are called as rolling grassland and also called shola grassland. It shows different types of vegetation like grasses, herbs, few shrubs and stunted trees.

Existence of two climax communities under the influence of same climatic conditions are found in higher mountain hill tops, above 7000 feet MSL (Mean sea level) of Nilgiris. Example: Sholas and grasslands.

3. Riparian Vegetation

This type of vegetation is located along streams and rivers. The most common species are, Terminalia, Diospyros,Salix,Ficus and grasses. They are found on the banks of Godavari, Krishna, Ganga, Brahmaputria, Narmadha Yamuna and riverbeds of Cauvery and Thamirabharani in Tamil Nadu.

4. Aquatic And Semi-Aquatic Vegetation

This type of vegetation is found in lakes, ponds, puddles and marshy places. The common plant species are Nelumbo, Nymphaea, Bacopa, Typha, Pandanus, Cyperus, Aeschynomene, Hydrilla, Aponogeton and Potomogeton. It is found in various parts of Tamil Nadu.

UNIT 8 -ENVIRONMENTAL ISSUES

After understanding the structure and functions of major ecosystems of the world, now student community should observe and understand environmental problems of their surroundings at local, national and international level. Now we are going to understand some of the environmental issues such asEnvironmental issues are the problems and harmful effects created by human's unmindful activity and over utilisation of valuable resources obtained from the nature (environment). Student should understand not only the environmental issues we are facing now, but also find solutions to rectify or reduce these problems.

Countries of the whole world agree that something needs to be done about these important environmental issues. Many global summits, conferences and conventions are regularly conducted by the United Nations and many steps are taken to minimise human-induced issues by signing agreements with around 150 countries.

Drastic increase in population resulted in demand for more productivity of food materials, fibres, fuels which led to many environmental issues in agriculture, land use modifications resulting in loss of biodiversity, land degradation, reduction in fresh water availability and also resulting in man-made global warming by green house gases even altering climatic conditions.

Green House effect and Global Warming

Green House Effect is a process by which radiant heat from the sun is captured by gases in the atmosphere that increase the temperature of the earth ultimately. The gases that capture heat are called Green House Gases which include carbon dioxide (CO2), methane (CH4), Nitrous Oxide (N2O) and a variety of manufactured chemicals like chlorofluorocarbon (CFC). Increase in greenhouse gases lead to irreversible changesin major ecosystems and climate patterns. For example, coral ecosystem is affected by increase in temperature, especially coral bleaching observed in Gulf of Mannar, Tamil Nadu.

Human activities lead to produce the green house effect by

- Burning fossil fuels, which releases CO2 and CH4
- Way of Agriculture and animal husbandry practices
- Electrical gadgets like refrigerator and air conditioners release chlorofluoro carbons
- The fertilizers used in Agriculture which release N2O
- The emissions from automobiles.

The increase in mean global temperature (highest in 4000 years) due to increased concentration of green house gases is called global warming.

One of the reasons for this is over population which creates growing need for food, fibre and fuel and considered to be the major cause of global warming.

Effects of Global Warming

- Rise in global temperature which causes sea levels to rise as polar ice caps and glaciers begin to melt causing submergence of many coastal cities in many parts of the world.
- There will be a drastic change in weather patterns bringing more floods or droughts in some areas.
- Biological diversity may get modified, some species ranges get redefined. Tropics and sub-tropics may face the problem of decreased food production.

Sources of Green House Gases Emission (Natural and Anthropogenic)

CO_2 (Carbon dioxide)

- Coal based power plants, by the burning of fossil fuels for electricity generation.
- Combustion of fuels in the engines of automobiles, commercial vehicles and air planes contribute the most of global warming.

- Agricultural practices like stubble burning result in emission of CO2.
- Natural from organic matter, volcanoes, warm oceans and sediments.

Methane

Methane is 20 times as effective as CO_2 at trapping heat in the atmosphere. Its sources are attributed paddy cultivation, cattle rearing, bacteria in water bodies, fossil fuel production, ocean, non-wetland soils and forest / wild fi res.

N_2O (Nitrous oxide)

It is naturally produced in Oceans from biological sources of soil and water due to microbial actions and rainforests. Man-made sources include nylon and nitric acid production, use of fertilizers in agriculture, manures cars with catalytic converter and burning of organic matter.

Global Warming Effects on Plants

- Low agricultural productivity in tropics
- Frequent heat waves (Weeds, pests, fungi need warmer temperature)
- Increase of vectors and epidemics
- Strong storms and intense flood damage
- Water crisis and decreased irrigation
- Change in flowering seasons and pollinators
- Change in Species distributional ranges
- Species extinction

Strategies to deal with Global Warming

- Increasing the vegetation cover, grow more trees
- Reducing the use of fossil fuels and green house gases
- Developing alternate renewable sources of energy
- Minimising uses of nitrogeneous fertilizers, and aerosols.

Ozone depletion

Ozone layer is a region of Earth's stratosphere that absorbs most of the Sun's ultra violet radiation. Th e ozone layer is also called as the ozone shield and it acts as a protective shield, cutting the ultra- violet radiation emitted by the sun. Just above the atmosphere there are two layers namely troposphere (the lower layer) and stratosphere (the upper layer). Th e ozone layer of the troposphere is called bad ozone and the ozone layer of stratosphere is known as good ozone because this layer acts as a shield for absorbing the UV radiations coming from the sun which is harmful for living organismscausing DNA damage. The thickness of the ozone column of air from the ground to the top of the atmosphere is measured in terms of Dobson Units.

Ozone is a colourless gas, reacts readily with air pollutants and cause rubber to crack, hurt plant life, damages lung tissues. But ozone absorbs harmful ultra violet β (uv-β) and UV – α radiation from sunlight. What is Dobson Unit? DU is the unit of measurement for total ozone. One DU (0.001 atm. cm) is the number of molecules of ozone that would be required to create a layer of pure ozone 0.01 millimetre thick at a temperature of 0° C and a pressure of 1 atmosphere (atm = the air pressure at the surface of earth). Total ozone layer over the earth surface is 0.3 centrimetres (3 mm) thick and is written as 300 DU. Th e false colour view of total ozone - Th e purple and blue colours are where there is the least ozone, and the yellows and reds are where there is more ozone.

The ozone shield is being damaged by chemicals released on the Earth's surface notably the chlorofluorocarbons widely used in refrigeration, aerosols, chemicals used as cleaners in many industries. The decline in the thickness of the ozone layer over restricted area is called Ozone hole.

September 16 is WORLD OZONE DAY

Ozone depletion in the stratosphere results in more UV radiations especially UV B radiations (shortwaves). UV B radiation destroys biomolecules (skin ageing) and damages living tissues. UV – C is the most damaging type of UV radiation, but it is completely filtered by the atmosphere (ozone layer). UV – a contribute 95% of UV radiation which causes tanning burning of skin and enhancing skin cancer. Hence the uniform ozone layer is critical for the wellbeing of life on earth.

During 1970's research findings indicated that man-made chlorofluorocarbons (CFC) reduce and convert ozone molecules in the atmosphere. The threats associated with reduced ozone pushed the issue to the forefront of global climate issues and gained promotion through organisation such as World Meterological Organisation and the United Nations. The Vienna Convention was agreed upon at the Vienna conference of 1985 but entered into force in 1988 provided the frameworks necessary to create regulative measures in the form of the Montreal protocol. The International treaty called the Montreal Protocol (1987) was held in Canada on substances that deplete ozone layer and the main goal of it is gradually eliminating the production and consumption of ozone depleting substances and to limit their damageon the Earth's ozone layer.

Clean Development Mechanism (CDM) is defined in the Kyoto protocol (2007) which provides project based mechanisms with two objectives to prevent dangerous climate change and to reduce green house gas emissions. CDM projects helps the countries to reduce or limit emission and stimulate sustainable development.

An example for CDM project activity, is replacement of conventional electrification projects with solar panels or other energy efficient boilers. Such projects can earn Certified Emission Reduction (CER) with credits / scores, each equivalent to one tonne of CO2, which can be counted towards meeting Kyoto targets.

Plant indicators

The presence or absence of certain plants indicate the state of environment by their response. The plant species or plant community acts as a measure of environmental conditions, it is referred as biological indicators or phytoindicators or plant indicators.

Plants	**Indicator for**
Lichens, Ficus, Pinus, Rose	SO_2 Pollution
Petunia, Chrysanthemum	Nitrate
Gladiolus	Flouride Pollution
Robinia pseudoacacia (Black locust tree)	Indicator of heavy metal contamination

Effects of Ozone depletion

The main ozone depletion effects are:

- Increases the incidence of cataract, throatand lung irritation and aggravation ofasthma or emphysema, skin cancer anddiminishing the functioning of immunesystem in human beings.
- Juvenile mortality of animals.
- Increased incidence of mutations.
- In plants, photosynthetic chemicals will beaffected and therefore photosynthesis willbe inhibited. Decreased photosynthesis willresult in increased atmospheric CO2 resulting in global warming and also shortage of foodleading to food crisis.
- Increase in temperature changes the climateand rainfall pattern which may result inflood / drought, sea water rise, imbalance inecosystems affecting flora and fauna.

Forestry
Agro forestry

Agroforestry is an integration of trees, crops and livestock on the same plot of land. The main objective is on the interaction among them. Example: intercropping of two or more crops between different species of trees and shrubs, which results in higher yielding and reducing the operation costs. This intentional combination of agriculture and forestry has varied benefits including increased bio-diversity and reduced erosion.

Some of the major species cultivated in commercial Agroforestry include Casuarina, Eucalyptus, MalaiVembu, Teak and Kadambu trees which were among the 20 species identified as commercial timber. They are of great importance to wood-based industries.

Benefits of agroforestry

- It is an answer to the problem of soil andwater conservation and also to stabilisethe soil (salinity and water table) reducelandslide and water run-off problem.
- Nutrient cycling between species improvesand organic matter is maintained.
- Trees provide micro climate for crops andmaintain O_2 – CO_2 balanced, atmospherictemperature and relative humidity.
- Suitable for dry land where rainfall isminimum and hence it is a good system foralternate land use pattern.
- Multipurpose tree varieties like Acacia areused for wood pulp, tanning, paper andfirewood industries.
- Agro-forestry is recommended for thefollowing purposes. It can be used asFarm Forestry for the extension of forests,mixed forestry, shelter belts and linear stripplantation.

Rehabilitation of degraded forests and recreation forestry

The production of woody plants combined with pasture is referred to silvopasture system. The trees and shrubs may be used primarily to produce fodder for livestock or they may be grown for timber, fuel wood and fruit or to improve the soil.

This system is classified into following categories.

i. Protein Bank: In this various multipurposetrees are planted in and around farmlands and range lands mainly for fodderproduction.

   Example: Acacia nilotica, Albizzia lebbek,Azadirachtaindica, Gliricidiasepium,Sesbania grandiflora.

ii. Livefence of fodder trees and hedges:Various fodder trees and hedges are plantedas live fence to protect the property fromstray animals or other biotic influences.
   Example: Gliricidiasepium, Sesbaniagrandiflora, Erythrina spp., Acacia spp..

Social forestry

It refers to the sustainable management of forests by local communities with a goal of climate carbon sequestration, change mitigation, depollution, deforestation, forest

restoration and providing indirect employment opportunity for the youth. Social forestry refers to the management of forests and afforestation on barren lands with the purpose of helping the environmental, social and rural development and benefits. Forestry programme is done for the benefit of people and participation ofthe people. Trees grown outside forests by government and public organisation reduce the pressure on forests.

In order to encourage tree cultivation outside forests, Tree cultivation in Private Lands was implemented in the state from 2007-08 to 2011-12.It was implemented by carrying out blockplanting and inter-crop planting with profitabletree species like Teak, Casuarina, Ailanthus,Silver Oak, etc. in the farming lands and by afree supply of profitable tree species for plantingin the bunds. The Tank foreshore plantationshave been a major source of firewood in TamilNadu. The 32 Forestry extension centresprovide technical support for tree growing inrural areas in Tamil Nadu. These centres providequality tree seedlings like thorn / thornlessbamboo, casuarinas, teak, neem, Melia dubia,grafted tamarind and nelli, etc. in private landsand creating awareness among students bytraining / camps.

Major activities of forestry extension centres

- Training on tree growing methods
- Publicity and propaganda regarding treegrowing
- Formation of demonstration plots
- Raising and supply of seedlings on subsidy
- Awareness creation among school childrenand youth about the importance of foreststhrough training and camps.

Deforestation

Deforestation is one of the major contributors to enhance green house effect and global warming. The conversion of forested area into a non-forested area is known as deforestation. Forests provide us many benefits including goods such as timber, paper, medicine and industrial products. The causes are

- The conversion of forests into agriculturalplantation and livestock ranching is a majorcause of deforestation.
- Logging for timber
- Developmental activities like roadconstruction, electric tower lines and dams.
- Over population, Industrialisation,urbanisation and increased global needs.

Effects of deforestation

- Burning of forest wood release storedcarbon, a negative impact just opposite ofcarbon sequestration.

- Trees and plants bind the soil particles. Theremoval of forest cover increases soil erosionand decreases soil fertility. Deforestation indry areas leads to the formation of deserts.
- The amount of runoff water increases soilerosion and also creates flash flooding, thusreducing moisture and humidity.
- The alteration of local precipitation patternsleading to drought conditions in manyregions. It triggers adverse climatic conditions and alters water cycle in ecosystem.
- It decreases the bio-diversity significantly astheir habitats are disturbed anddisruptionof natural cycles.
- Loss of livelihood for forest dwellers andrural people.
- Increased global warming and account forone-third of total CO_2 emission.
- Loss of life support resources, fuel, medicinal herbs and wild edible fruits.

Afforestation

Afforestation is planting of trees where there was no previous tree coverage and the conversion of non-forested lands into forests by planting suitable trees to retrieve the vegetation. Example: Slopes of dams afforested to reduce water run-off, erosion and siltation. It can also provide a range of environmental services including carbon sequestration, water retention.

The Man who Single Handedly Created a Dense Forest
Jadav "Molai" Payeng (born 1963) is an environmental activist has single-handedly planted a forest in the middle of a barren wasteland. This Forest Man of India has transformed the world's largest river island, Majuli, located on one of India's major rivers, the Brahmaputra, into a dense forest, home to rhinos, deers, elephants, tigers and birds. And today his forest is larger than Central Park.

Former vice-chancellor of Jawahar Lal Nehru University, Sudhir Kumar Sopory named Jadav Payeng as Forest Man of India, in the month of October 2013. He was honoured at the Indian Institute of Forest Management during their annual event 'Coalescence'. In 2015, he was honoured with Padma Shri, the fourth highest civilian award in India. He received honorary doctorate degree from Assam Agricultural University and Kaziranga University for his contributions.

Afforestation Objectives

- To increase forest cover, planting more trees,increases O2 production and air quality.
- Rehabilitation of degraded forests toincrease carbon fixation and reducing $CO_2$from atmosphere.
- Raising bamboo plantations.
- Mixed plantations of minor forest produceand medicinal plants.
- Regeneration of indigenous herbs / shrubs.

- Awareness creation, monitoring andevaluation.
- To increase the level and availability of watertable or ground water and also to reducenitrogen leaching in soil and nitrogencontamination of drinking water, thusmaking it pure not polluted with nitrogen.
- Nature aided artificial regeneration.

Achievements

- Degraded forests were restored
- Community assets like overhead tanksbore-wells, hand pumps, community halls,libraries, etc were established
- Environmental and ecological stability wasmaintained.
- Conserved bio-diversity, wildlife and genetic resources.
- Involvement of community especiallywomen in forest management.

Agrochemicals and their effects

An agro-chemical is useful in managing agriculture or in farming area which is one of the major issues of the environment. Agro-chemicals includes fertilizers, liming and acidifying agents, soil conditioners, pesticides and chemicals used in animal husbandry, such as antibiotics and hormones.

Excessive use of fertilizers and pesticides leads to the contamination of groundwater and makes it non-potable, ultimately affecting the soil fertility. Most of the chemical fertilizers contain varying amounts of nitrogen, phosphorous, potassium and nutrients that plants need to grow. Soil acidity influences C and N cycles by affecting soil microbes, also green house gas flux in soils and affect bio availability of N, P, S like major nutrients. This makes the soil too acidic or alkaline so that it becomes difficult for the plants to survive. These residues and synthetic chemicals like DDT (dichloro diphenyl trichloro ethane) and PCBs (polychlorinated biphenyls) cause nutrient and pH imbalance and quality reduction of agricultural produce. This problem can be minimised by sustainable agriculture.

Pesticides increase incidence of brain, blood cancer and neurotoxicity, Parkinson like symptoms, infertility, birth defects, reproductive and behavioural disorders.

- Nitrates from fertilizers interact with the haemoglobin to form methyl haemoglobin. This reduces oxygen uptake, results in Blue baby syndrome (cyanosis) and hypoxia. Nitrates vasodilate and reduce blood pressure.
- Bio-magnification: Pollutants, toxic substances increase in water move from one food chain to many and finally reach human being and this process of bio-amplification or increase in concentration is called bio-magnification.

Alien invasive species

Invasion of alien or introduced species disrupts ecosystem processes, threaten biodiversity,reduce native herbs, thus reducing the ecosystem services (benefits). During eradication of these species, the chemicals used increases greenhouse gases. Slowly they alter ecosystem, micro climate and nature of soil and make it unsuitable for native species and create human health problems like allergy, thus resulting in local environmental degradation and loss of important local species.

According to World Conservation Union invasive alien species are the second most significant threat to bio-diversity after habitat loss.

What is invasive species?

A non-native species to the ecosystem or country under consideration that spreads naturally, interferes with the biology and existence of native species, poses a serious threat to the ecosystem and causes economic loss.

It is established that a number of invasive species are accidental introduction through ports via air or sea. Some research organisations import germplasm of wild varieties through which also it gets introduced. Alien species with edible fruits are usually spread by birds.

Invasive species are fast growing and are more adapted. They alter the soil system by changing litter quality thereby affecting the soil community, soil fauna and the ecosystem processes.
It has a negative impact on decomposition in the soils by causing stress to the neighbouring native species. Some of the alien species which cause environmental issues are discussed below

Eichhorniacrassipes

It is an invasive weed native to South America. It was introduced as aquatic ornamental plant, which grows faster throughout the year. Its widespreadgrowth is a major cause of biodiversity loss worldwide. It affects the growth of phytoplanktons and finally changing the aquatic ecosystem.

It also decreases the oxygen content of the waterbodies which leads to eutrophication. It poses a threat to human health because it creates a breeding habitat for disease causing mosquitoes (particularly Anopheles) and snails with its free floating dense roots and semi submerged leaves. It also blocks sunlight entering deep and the waterways hampering agriculture, fisheries, recreation and hydropower.

Lantana camara

Identified as one of the worst invasive species by Global Invasive Species Database. It is also an invasive weed native to South America introduced as ornamental plant. It occupies a widely adaptable range of habitats.

This species is spread by birds It exerts allelopathic effect, which reduces the growth of surrounding plants by inhibiting germination and root elongation. Root removal and bio-control are the best methods to control. Now tribes are trained to use the stem as fibre for making household materials like baskets, furniture and even cots.

Parthenium hysterophorus

Parthenium hysterophorus native to South America introduced accidently into many regions of the world along with imported food grains. It is a harmful weed in the forest which suppresses the growth of native species and reduces the availability of fodder for animals It infests pastures and farmland causing often loss of yield. The plant produces allelopathic chemicals that suppress crop and native plants and its pollen causes allergic rhinitis and asthma, dermatitis in humanbeing.

Prosopis juliflora

Prosopis juliflora is an invasive species native to Mexico and South America. It was first introduced in Gujarat to counter desertification and later on in Andhra Pradesh, Tamil Nadu as a source of firewood. It is an aggressive coloniser and as a consequence the habitats are rapidly covered by this species. Its invasion reduced the cover of native medicinal herbaceous species. It is used to arrest wind erosion and stabilize sand dunes on coastal and desert areas. It can absorb hazardous chemicals from soil and it is the main source of charcoal.

Conservation

India due to its topography, geology and climate patterns has diverse life forms. Now this huge diversity is under threat due to many environmental issues for this conservation becomes an important tool by which we can reduce many species getting lost from our native land. By employing conservation management strategies like germplasm conservation, in situ, ex-situ, in-vitro methods, the endemic as well as threatened species can be protected.

In-situ conservation

It means conservation and management of genetic resources in their natural habitats. Here the plant or animal species are protected within the existing habitat. Forest trees, medicinal and aromatic plants under threat are conserved by this method. This is carried out by thecommunity or by the State conservation which include wildlife, National park and Biosphere reserve. The ecologically unique and biodiversity rich regions are legally protected as wildlife sanctuaries, National parks and Biosphere

reserves. Megamalai, Sathyamangalam wildlife, Guindy and Periyar National park, and Western ghats, Nilgiris, Agasthyamalai and Gulf of Mannar are the biosphere reserves of Tamil Nadu.

Sacred groves

These are the patches or grove of cultivated trees which are community protected and are based on strong religious belief systems which usually have a significant religious connotation for protecting community. Each grove is an abode of a deity mostly village God Or Goddesses like Aiyanar or Amman. 448 grooves were documented throughout Tamil Nadu, of which 6 groves (Banagudi shola, Thirukurungudi and Udaiyankudikadu, Sittannnavasal, Puthupet and Devadanam) were taken up for detailed floristic and faunistic studies. These groves provide a number of ecosystem services to the neighbourhood like protecting watershed, fodder, medicinal plants and micro climate control.

Ex-situ conservation

It is a method of conservation where species are protected outside their natural environment. This includes establishment of botanical gardens, zoological parks, conservation strategies such as gene, pollen, seed, in-vitro conservation, cryo preservation, seedling, tissue culture and DNA banks. These facilities not only provide housing and care for endangered species, but also have educational and recreational values for the society

International Union for Conservation of Nature (IUCN)

Founded in 1948, the International Union for Conservation of Nature (IUCN) is the world's oldest environmental organisation with its headquarters at Gland, Switzerland. It is a neutral forum for Governments, NGO's, Scientists, business and local communities with the aim of developing solution and implementing policies related to the conservation of environment and sustainable development.

IUCN Red List

IUCN Red List categories help us to evaluate the degree of threat and conservation priorities to the flora and fauna It is also a powerful tool forpersuading governments to protect threatened species and for most of the plant and animal species world-wide. IUCN has developed protected areas and developed criteria for threatened species. The criteria are as follows.

Conservation movement

A community level participation can help in preservation and conservation of our environment. Our environment is a common treasure for all the living organisms on

earth. Every individual should be aware of this and participate actively in the programs meant for the conservation of the local environment. Indian history has witnessed many people movements for the protection of environment.

Chipko Movement

The tribal women of Himalayas protested against the exploitation of forests in 1972. Later on it transformed into Chipko Movement by Sundarlal Bahuguna in Mandal village of Chamoli district in 1974. People protested by hugging trees together which were felled by a sports goods company. Main features of Chipko movement were,

- This movement remained non political
- It was a voluntary movement based onGandhian thought.
- It was concerned with the ecological balance of nature
- Main aim of Chipko movement was to give a slogan of five F's – Food, Fodder, Fuel, Fibreand Fertilizer, to make the communities selfsufficient in all their basic needs.

Appiko Movement

The famous Chipko Andolen of Uttarakhand in the Himalayas inspired the villagers of Uttar Karnataka to launch a similar movement to save their forests. This movement started in Gubbi Gadde a small village near Sirsi in Karnataka by Panduranga Hegde. This movement started to protest against felling of trees, monoculture, forest policy and deforestation.

A - Population reduction
B - Geographic range
C - Small population size and decline
D - Very small or restricted population
E - Quantitative analysis

IUCN Red List categories
Extint (EX)

A taxon is Extinct when there is no reasonable doubt on the death of the last individual. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Example: Neuracanthusneesianus.

Extinct in the wild (EW)

A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalised population (or populations) well outside the past range. Example: Ginkgo biloba

Critically endangered (CR)

A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered, and it is therefore considered to be facing an extremely high risk of extinctions in the wild. Example: Euphorbia santapaui, Piper barberi, Syzygiumgambelianum.

Endangered (EN)

A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered, and it is therefore considered to be facing a very high risk of extinction in the wild. Example: Elaeocarpus venustus, Pogostemonnilagricus, Eugenia singampattiana.

Vulnerable (VU)

A taxon is Vulnerable when the best available evidence indicates that it meets any other criteria A to E for Vulnerable, and it is therefore considered to be facing a high risk of extinction in the wild. Example: Dalbergialatifolia, Santalum album, Chloroxylonsweitenia

Near threatened (NT)

A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for threatened category in the near future.

Least concerned (LC)

A taxon is Least Concerned when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened, Widespread and abundant taxa are included in this category.

Data deficient (DD)

A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of the risk of extinction based on its distribution and/or population status.

Not evaluated (NE)

A taxon is Not Evaluated when it has not yet been evaluated against the criteria.

Endemic Centres and Endemic Plants

Endemic species are plants and animals that exist only in one geographic region. Species can be endemic to large or small areas of the earth. Some are endemic to a particular continent, some to a part of a continent and others to a single island.Any species found restricted to a specified geographical area is referred to as ENDEMIC.

It may be due to various reasons such as isolation, interspecific interactions, seeds dispersal problems, site specificity and many other environmental and ecological problems. There are 3 Megacentres of endemism and 27 microendemic centres in India.

Approximately one third of Indian flora have been identified as endemic and found restricted and distributed in three major phytogeographical regions of india, that is Indian Himalayas, Peninsular India and Andaman nicobar islands. Peninsular India, especially Western Ghats has high concentration of endemic plants. Hardwickiabinata and Bentinckiacondapanna are good examples for endemic plants. A large percentage of Endemic species are herbs and belong to families such as Poaceae. Apiaceae, Asteraceae and Orchidaceae.

Endemic Plants	**Habit**	**Name of Endemic centre**
Baccaurea	Tree	Southern Western
Agasthiyamalaia	Tree	Peninsular India
Hardwickia binata	Tree	Peninsular and northern India
Bentinckia condappana	Tree	Western ghats of Tamil Nadu and Kerala
Nepenthes Khasiyana	Liana	Khasi hills, Meghalaya

Majority of endemic species are threatened due to their narrow specific habitat, reduced seed production, low dispersal rate, less viable nature and human intereferences. Serious efforts need to be undertaken for their conservation, otherwise these species may become globally extinct.

Carbon Capture and Storage (CCS)

Carbon capture and storage is a technology of capturing carbondioxide and injects it deep into the underground rocks into a depth of 1 km or more and it is an approach to mitigate global warming by capturing CO_2 from large point sources such as industries and power plants and subsequently storing it instead of releasing it into the atmosphere. Various safe sites have been selected for permanent storage in various deep geological formations, liquid storage in the Ocean and solid storage by reduction of CO_2 with metal oxide to produce stable carbonates. It is also known as Geological sequestration which involves injecting CO_2 directly into the underground geological formations (such as declining oil fields, gas fields saline aquifers and unmineable coal have been suggested as storage sites).

Carbon Sink

Any system having the capacity to accumulate more atmospheric carbon during a given time interval than releasing CO_2. Example: forest, soil, ocean are natural sinks. Landfills are artificial sinks.

Carbon Sequestration

Carbon sequestration is the process of capturing and storing CO_2 which reduces the amount of CO_2 in the atmosphere with a goal of reducing global climate change.

Carbon sequestration occurs naturally by plants and in ocean. Terrestrial sequestration is typically accomplished through forest and soil conservation practices that enhance the storage carbon.

As an example microalgae such as species of Chlorella, Scenedesmus, Chroococcus and Chlamydomonas are used globally for CO2 sequestration. Trees like Eugenia caryophyllata, Tecomastans, Cinnamomumverum have high capacity and noted to sequester carbon macroalgae and marine grasses and mangroves are also have ability to mitigate carbon-di-oxide.

Carbon Foot Print (CFP)

Every human activity leaves a mark just like our footprint. This Carbon foot print is thetotal amount of green house gases produced by human activities such as agriculture, industries, deforestation, waste disposal, buring fossil fuels directly or indirectly. It can be measured for an individual, family, organisation like industries, state level or national level. It is usually estimated and expressed in equivalent tons of CO2 per year. The burning of fossil fuels releases CO2and other green house gases. In turn these emissions trap solar energy and thus increase the global temperature resulting in ice melting, submerging of low lying areas and inbalance in nature like cyclones, tsunamis and extreme weather conditions. To reduce the carbon foot print we can follow some practices like

(i) Eating indigenous fruits and products
(ii) Reduce use of your electronic devices
(iii) Reduce travelling
(iv) Do not buy fast andpreserved, processed, packed foods.
(v) Plant agarden
(vi) Less consumption of meat and seafood. Poultry requires little space, nutrients andless pollution comparing cattle farming.
(vii) reduce use of Laptops (when used for 8 hours, itreleases nearly 2 kg. of CO_2 annually)
(viii) Linedry your clothes. (Example: If you buy importedfruit like kiwi, indirectly it increases CFP.How? The fruit has travelled a long distance inshipping or airliner thus emitting tons of CO2)

Biochar

Biochar is another long term method to store carbon. To increase plants ability to store more carbon, plants are partly burnt such as crop waste, waste woods to become carbon rich slow decomposing substances of material called Biochar. It is a kind of charcoal used as a soil amendment. Biochar is a stable solid, rich in carbon and can endure in soil for thousands of years. Like most charcoal, biochar is made from biomass via pyrolysis. (Heating biomas in low oxygen environment) which arrests wood from complete burning. Biochar thus has the potential to help mitigate climate change via carbon sequestration. Independently, biochar when added to soil can increase soil fertility ofacidic soils, increase agricultural productivity, and provide protection against some foliar and soil borne diseases. It is a good method of preventing waste woods and logs getting decayed instead we can convert them into biochar thus converting them to carbon storage material.

Rain water harvesting – RWH (Solution to water crisis – A ecological problem)

Rainwater harvesting is the accumulation and storage of rain water for reuse in-site rather than allowing it to run off. Rainwater can be collected from rivers, roof tops and the water collected is directed to a deep pit. The water percolates and gets stored in the pit. RWH is a sustainable water management practice implemented not only in urban area but also in agricultural fields, which is an important economicalcost effective method for the future.

Environmental benefits of Rain Water Harvesting:

- Promotes adequacy of underground waterand water conservation.
- Mitigates the effect of drought.
- Reduces soil erosion as surface run-off isreduced.
- Reduces flood hazards.
- Improves groundwater quality and watertable / decreases salinity.
- No land is wasted for storage purpose andno population displacement is involved.
- Storing water underground is an eco-friendly measure and a part of sustainablewater storage strategy for local communities.

Importance of Lakes

Water bodies like lakes, ponds not only provide us a number of environmental benefits but they strengthen our economy as well as our quality of life like health. Lakes as a storage of rain water provides drinking water, improves ground water level and preserve the fresh water bio-diversity and habitat of the area where in occurs.

In terms of services lakes offer sustainable solutions to key issues of water management and climatic influences and benefits like nutrient retention, influencing local rainfall, removal of pollutants, phosphorous and nitrogen and carbon sequestration.

Important lakes in Tamil Nadu

Lakes are man-made surface water harvesting systems. They are useful for irrigation, drinking, fishing and recreation purposes. It is the responsibility of the individuals as well as communities collectively to maintain and manage water bodies. Understanding catchment areas help us to halt the degradation of water bodies and protecting it from getting polluted.

SholavaramLake : It is located in Ponneri Taluk of Thiruvallur District. It is one of the rain fed reservoir from where water is drawn for supply to Chennai city. The full capacity of the lake is 65.5 ft. Built in the British era this lake is responsible for treating the guests to water sports too. This lake is rich in varied species of flora and fauna.

Chembarampakkam Lake: It is located about 25 km. from Chennai. This lake is 500 yrs old. This lake is a rain fed water body which aids the Chennai City in its water supply. A river named Adyar also incepts from this lake which acts as the primary outflow for this reservoir. This lake is spread over an area of 15 square km.

Maduranthakam Lake: It is located in Kancheepuram district and it is a man-made creation. An ideal spot for an evening picnic, the widespread pristine waters of the lake are an exceptionally calming sight. The full capacity of the reservoir is 23.3ft. Kiliyar is a small river that originates from Madhuranthagam reservoir. It spreads to an area of 2908 acres and was built by Uttama Chola and the boundaries (stretched upto 12960 feet) are strengthened by Britishers with a storing capacity of 690 million cu.feet. Rain water from Cheyyar, Thiruvannamalai and Vandavasi reaches this lake.

Sewage disposal

Sewage disposal treatment helps to transform raw sewage into an easier manageable waste and to retrieve and reuse treated residual sewage materials. Greenhouse gases like carbon-dioxide, methane, nitrous oxide are produced during sewage treatment which apart from causing the impact on the atmosphere, it also affect the urban ecosystem, aquatic ecosystems. By making use of advanced disposal treatment plants, climate change and pollution can be minimised.

Sewage is waste matter such as faeces or used dirty water from homes and factories, which flows away through sewers. Sewage treatment is the process of removing contaminants from waste water, primarily from household sewage. Physical, chemical and biological processes are used to remove contaminants and produce

treated waste water, that is safer for the environment. Sewage contains large amounts of organic matter and microbes. This cannot be discharged into natural water bodies like rivers and streams directly. Hence sewage is treated in sewage treatment plants (STPs) to make it lessSewage treatment generally involves three stages, called primary, secondary and tertiary treatment.

Solid waste management

Solid waste refers to all non liquid wastes which causes health problems and unpleasant living environment leading to pollution. Solid waste management is a term that is used to refer to the process of collecting and treating solid wastes. It is all about how it can be changed and recycled as a valuable resource.

Methods of solid waste management includes Landfill, incineration, recovery, recycling, composting, and pyrolysis.

- Technologicaladvancement for processingtreatment and disposal of solidwaste helps in converting it intorenewable energy and organicmanure.
- Electronicwaste contains toxic materials and are found to be non-biodegradable which causes threat to human health and the smoke during recycling and leaching causes great threat to water bodies. Agricultural landfills method stands a good method to reduce these problems.

Liquid Waste Management

Liquid waste includes point source and non-point source discharges such as storm water and waste water. Examples of liquid waste include wash water from homes, liquids, used for cleaning in industries and waste detergents.

Grey water is the one from municipal waste which contains harmful pathogens. Water coming from domestic equipments other than toilets (bathtub, showers, sinks, and washing machine) is also referred as grey water. Municipal wastes can be detoxified biologically and then recycled. Domestic waste water can be recycled and used for gardening.

Environmental Impact Assessment (EIA)

Environmental Impact Assessment is an environmental management tool. It helps to regulate and recommend optimal use of natural resources with minimum impact on ecosystem and biotic communities. It is used to predict the environmental consequences of future proposed developmental projects (example: river projects, dams, highway projects) taking into account inter-related socio-economic, cultural and human-health impacts. It reduces environmental stress thus helping to shape the projects that may suit local environment by ensuring optimal utilization of natural resources and disposal of wastes to avoid environmental degradation.

The benefits of EIA to society

- A healthier environment
- Maintenance of biodiversity
- Decreased resource usage
- Reduction in gas emission and environmentdamage

Biodiversity Impact Assessment (BIA)

Biodiversity Impact Assessment can be defined as a decision supporting tool to help biodiversity inclusive of development, planningand implementation. It aims at ensuring development proposals which integrate bio-diversity considerations. They are legally compliant and include mechanisms for the conservation of bio-diversity resources and provide fair and equitable sharing of the benefits arising from the use of bio-diversity.

Biomonitoring

The act of observing and assessing the current state and ongoing changes in ecosystem, biodiversity components, landscape including natural habitats, populations and species.

An agricultural drone is an unmanned aerial vehicle applied to farming in order to help increased crop production and monitor crop growth. Agricultural drones let farmers see their fields from the sky. This bird's eye-view can reveal many issues such as irrigation problems, soil variation and pest and fungal infestations. It is also used for cost effective safe method of spraying pesticides and fertilizers, which proves very easy and non-harmful

Bio-diversity impacts can be assessed by

- Change in land use and cover
- Fragmentation and isolation
- Extraction
- External inputs such as emissions, effluentsand chemicals
- Introduction of invasive, alien or geneticallymodified species
- Impact on endemic and threatened flora andfauna.

Geographic Information System

GIS is a computer system for capturing, storing, checking and displaying data related to positionson Earth's surface. Also to manipulate, analyse, manage and present spacial or geographic data.

GPS is a satellite navigation system used to determine the ground position of an object. It is a constellation of approximately 30 well spaced satellites that orbit the earth and make it possible for the people with ground receivers to pinpoint their geographic location. Some applications in which GPS is currently being used for around the world include Mining, Aviation, Surveying Agricultural and Marine ecosystem.

Importance of GIS

- Environmental impact assessment
- Disaster management
- Zoning of landslide hazard
- Determination of land cover and land use
- Estimation of flood damage
- Management of natural resources
- Soil mapping
- Wetland mapping
- Irrigation management and identification ofvolcanic hazard
- Vegetation studies and mapping ofthreatened and endemic species.

Remote Sensing is the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance from the targeted area. It is an tool used in conservation practices by giving exact picture and data on identification of even a single tree to large area of vegetation and wild life for classification of land use patterns and studies, identification of biodiversity rich or less areas for futuristic works on conservation and maintenance of various species including commercial crop, medicinal plants and threatened plants.

Specific uses

- Helps predicting favourable climate, for thestudy of spreading of disease and control ingit.
- Mapping of forest fire and speciesdistribution.
- Tracking the patterns of urban areadevelopment and the changes in Farmlandor forests over several years
- Mapping ocean bottom and its resources
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Application of Satellites		
Name of the Satellites	Year of Launch	Application
SCATSAT - I	Sep. 2016	Weather forecasting, cyclone prediction and tracking services in India
INSAT 3DR	Sep. 2016	Disaster Management
CARTOSAT -2	Jan. 2018	Earth observation

GSAT -6A	March 2018	Communication
CARTOSAT– 2 (100TH Satellite)	Jan. 2018	To watch border surveillance