Uttar Pradesh Rajarshi Tandon Open University

Bachelor of Science

UGEVS-102 (N)

Ecology and Biodiversity Conservation

COURSE INTRODUCTION

In this course learner will to know about ecology and biodiversity conservation. The ecology is the study of the relationships between living organisms and their environment. Biodiversity conservation is the practice of protecting and preserving the variety of life forms on Earth. It involves safeguarding ecosystems, species, and genetic diversity to maintain ecological balance and sustain life on our planet. Conservation efforts aim to prevent the loss of species and habitats, often due to human activities such as deforestation, pollution, overfishing, and climate change. Strategies include establishing protected areas, implementing sustainable resource management, promoting habitat restoration, and raising awareness about the importance of biodiversity. By preserving biodiversity and promoting ecological balance, we can ensure the well-being of both the natural world and human societies, as we depend on the services and resources provided by healthy ecosystems. The course is organized into following blocks:

Block 1 covers the concept of ecology and their role in understanding of environment
Block 2 deals the understanding of ecosystem and its function in nature for natural balance
Block 3 describes about the natural diversity, its types and role in nature.

Rajarshi Tandon Open University, Prayagraj

Ecology and Biodiversity Conservation

Block- 1

Ecology

UNIT -1

Ecology and Environment

UNIT-2

Autecology

UNIT-3

Synecology

UGEVS-102

Rajarshi Tandon Open University, Prayagraj

Ecology and Biodiversity Conservation

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Unit-1: Ecology and Environment

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1.1. Introduction

The term ecology (oekologie) derived from two Greek words oikos means 'house' or place to live and logus means study. Ecology is the study of the relationships between living organisms, including humans, and their physical environment. It seeks to understand the vital connections between plants and animals, and the word around them. "Ecology" is the study of the environmental house including all the organism in it and all the functional process that make the house habitable with emphasis on the totality or pattern of relations between organism and their environment. The term ecology is defined in much diverse assemblage such as life cycles in biological, human and industrial ecosystem or population, through sharing similar, overall features in relation to corporate social responsibility. Ecology is the study of the inter-relationship between in the living organisms with their environment. Which includes both biotic and abiotic components, include the biodiversity, distribution, biomass and population of organisms, as well as cooperation and competition on within and between species. Eugene Odum is lionized throughout science as the father of modern ecology and recognized by the University of Georgia as the founder of Eugene P. Odum School of ecology, Georgia. Fundaments of ecology which Odum published in 1953 with his younger brother and fellow ecologist Howard. He pioneered the concept of ecosystem. The term ecology was coined by the German zoologist Ernst Haeckle in 1866 to describe the economics of living forms. Ramdeo Mishra is the father of Indian ecology and started the first postgraduate course of ecology in India. He worked to develop responses of plant population and productivity and nutrient cycling in tropical forest and grassland ecosystem.

A.G. Tansley (1935), the philosopher ecologist visualized a holistic approach of the study recognizing the fact that the biotic (living) and abiotic (non-living) components of nature are not only interrelated but also function in an orderly manner as a definite system. He proposed the term ecosystem for the set of organisms interacting with each other and their surrounding physical and chemical factors extant in a given space.

Objectives

- To discuss the history and scope of ecology
- To explain the specialized branches of ecology
- To discuss the major division of ecology
- To discuss the ecological levels of organization

1.2.Ecology and Environment

During the first third of 20th century, there started developing specialized area of ecology like paleo-ecology, zoogeography, oceanography, limnology etc. And then was introduced the population concept on which statistical studies and sampling techniques were employed for solving the community problems. This era is popularly called as era of population and community ecologists

The **scope of ecology** contains a wide array of interacting levels organization, Spanning micro level (eg; cells) to planetary scale (biosphere) phenomena. To structure the study of ecology into a conceptually manageable framework, the biological world of organized into a nested hierarchy , ranging in scale from genes, to cell, to tissues, to organs, to organisms, to species, to populations, to communities, to ecosystems, to biomes, and up to the level of the biosphere. Ecology first began gaining popularity in 1960, when environmental issues were rising to the forefront of public awareness. Although, scientists have been studying the natural word for countries, ecology is the modern scene has only been around since the 19^{th} century. Around this time European and American scientist began studying, how plant function and their effects on the habitats around them. Attainment of this goal requires the integration of scientific disciplines inside and outside of biology, such as biochemistry, physiology, evolution, biodiversity, molecular biology, geology and climatology. Some ecological research also applies aspects of chemistry and physics and it frequently uses mathematical model.

In ecology, **ecosystems** are composed of dynamically interacting parts, which include organisms the communities, they comprise and the non living (abiotic) components of their environment. Ecosystem processes, such as primary production, pedogenesis (the formation of soil), nutrient cycling, regulates the flow of energy and matter through an environment. These processes are sustained by organisms with specific life history traits. The variety of organisms called biodiversity, which refer to the different species, genes, and ecosystem.

Ecosystem simply means "ecological system". Ecology is defined as the study of ecosystems. Ecologist study the interaction of all the organisms in an ecosystem. The study includes complex interactions between thousands of plants and animals to the role of microbes living under the soil to the effects of tropical rainforest on the earth's atmosphere. The study done by ecologists can help us to better understand the world around us and can influence our lives in a positive way by improving the environment, managing our natural resources and protecting the public health.

Biodiversity describe the diversity of life from genes to ecosystems and spans every level of biological organization Biodiversity includes species diversity, ecosystem diversity , and genetic diversity. Biodiversity within ecosystem can be organized into trophic pyramids, in which the **vertical dimension** represent feeding relations that become further removed from the base of the food chain upto world top predators, and the **horizontal dimension** represents the abundance or biomass at each level. Ecologist interested in the features that influence the survival of an endangered species might use mathematical models to predict how current conservation efforts affects endangered organism. Ecologist study, several biological levels of organization, which include organism, population, community and ecosystem. There are many practical applications of ecology in conservation biology, wetland management, natural resource management (agriculture, forestry, agroforestry, and fisheries), city planning (urban ecology), community health, human social interaction (human ecology). Ecosystem sustain life supporting functions and produce natural capital, such as biomass production (food, fuel, fiber and medicine), the regulation of climate, global biogeochemical cycles, water filtration, soil formation, erosion control and flood protection.

Temperature influences the ecology and evolution of species. Organisms generally slow down or freeze when conditions are cold, but overheat and lose function as the temperature rises. At the community level, the ecologist study how resource availability which influences ecosystem characteristics, including the number and types of species present. For example, the amount of carbon and energy fixed in photosynthesis by plant and other producers (e.g. productivity) constrains the amount of consumers an ecosystem may support. Because of this limit it's lost at each transmission step through a food web. A low productivity ecosystem generally supports less consumer biomass than higher productivity systems.

The product of organic evolution is the origin of species or evolution of old species into new species. During organic evolution, under environmental stresses, the autotrophic, heterotrophic, anaerobic and aerobic prokaryotic cells of kingdom. Monera started symbiotic relationship and evolved into eukaryotic plant, and animal cells to form kingdom Protista (Margulis 1970). Later on, Kingdom Protista Evolved and gave origin to three kingdom Plantae (Metaphyta), Fungi and Animals (Metazoa).

Besides these major ecological subdivisions, there are specialized branches of ecology. There are many subcategories of ecology, such as ecosystem ecology, animal ecology and plant ecology, which look at the differences and similarities of various plants in various climates and habitats.

In addition, physiological ecology, studies the responses of the individual organism to the environment, while population ecology looks at the similarities and dissimilarities of populations and how they replace each other overtime. Finally, it is important to note that ecology is not synonymous with environment. It is also different it is closely related to the studies of evolutionary biology, genetics, and ethnology. Adaptation is the central unifying concept in behavioural ecology. Behavioural ecology is the study of an organisms behaviour in its environment and its ecological and evolutionary implications. Predator-prey interactions are an introductory concept into food web studies as well as behavioural ecology.

Social ecological behaviours are notable in the social insects, slime moulds, etc. Ecological interactions can be classified into a host and an associate relationship. A host is any entity that harbours another associate. Relationships within a species are mutually or reciprocally beneficial and are called mutualisms. Example of mutualisms includes fungus- growing agricultural symbiotic bacteria living in the guts of insect and other organisms. Lichens with fungi and photosynthetic algae and corals with photosynthetic algae are also examples of mutualism. There are various specific and detailed approaches in ecology which are as follows:

- **Habit ecology –** This includes studies on habitat, e.g. Fresh water ecology, Marine ecology, Forest ecology, Grassland ecology.
- **Population Ecology-** This deals with population dynamics in pure or mixed strands. Population ecology is the branch of ecology that studies the structure and dynamics of populations.
- **Human Ecology-** This study concerns the environment with man as main theme.
- **Palaeoecology-** A branch of ecology that is concerned with the characteristics of ancient environment and with their relationship to ancient plants and animals.
- **Ecosystem Ecology-** It deals with the analysis of components of ecosystem and the interrelationship of biotic and abiotic components.
- **Radiation Ecology-** It deals with the study of radioactive substances and radiations in the environment.
- **Space Ecology-** This is concerned with a possible visit to and returns from neighboring planets.
- **Statistical Ecology-** It deals with the statistical studies on populations, sampling techniques and community problems.
- **Applied Ecology-** It deals with the soil erosion, environmental pollution, wild life management etc.
- **Zoogeography-** It deals with geographic distribution of animals.
- **Phytogeography-** It deals with geographic distribution of plants.

1.3.Types of ecology

Early ecologist has recognized two major subdivision of ecology in particular reference to animals or to plants, hence animal ecology and plant ecology. Further, ecology is often broadly divided into autecology and Synecology.

Depending upon the levels of organization, synecology deal with population, community, biome, and ecosystem

1.3.1. Animal ecology

Animal ecology is concerned witch the relationships of individuals to their environments, including physical factors and other organisms and the consequences of these relationships for evolution, population growth and regulation, interactions between species, the composition of biological communities and energy flow.

1.3.2. Plant ecology

Plant ecology is the study of the relationship of plants with the biotic (living organisms such as animals and other plants, bacteria and fungi) and abiotic factors such as moisture, temperature, sunlight, soil (nutrients and salinity) and water surrounding them.

1.3.3. Autecology

Autecology is the study of individual organism or individual species. It is also called as population ecology. Autecology study is the interrelationship between individual species of organism or its population and its environment. In autecology we study in details the morphology of individuals affected by its prevailing environment. Its geographical distribution based on the surrounding influence of environment on the life cycle and growth of organism. Its taxonomical position and several factors include those which affect different developmental stages of individual's life cycle.

In autecology we study the details of their geographic distribution, morphology, taxonomic position and life cycle etc.

1.3.4. Synecology

It is also called the community ecology. Synecology is the study of group of organisms of different species, which are associated together as a unit, and in form of community. Synecology can be divided into population, community ecology, biome and ecosystem ecology.

1.4. Environmental factors

There are several ecological factors that affect on environment are such as

A. **Biotic Factor:-**

The biotic factors include the influence of all living organisms which interact with each other with abiotic components.

B. **Abiotic Factor:-**

Abiotic factors are all non living chemical and physical factors present in the atmosphere. Sunlight, air, minerals, water, salts, and soil are some examples of abiotic factors.

The abiotic components are characterized by physical and chemical factors such as light, temperature, rain fall, pressure, P^H, the content of oxygen and other gases.

1.4.1. Importance environmental factors

Environmental factors impact our health, this includes pollution in the air, carcinogens in food, and we eat, pesticides, lead, increased computer screen time lead to genetic damages that cause decrease. Environmental factors remain numerous, complex difficult to standardized

1.4.2. Role of environmental factors

Environmental factors are significant contributors to population health across the life course. Factors such as pH, temperature, dissolve oxygen, salinity are environmental variable affects energy-generating pathways. Environmental factors are stressful when they are limited supply or in excess. Environmental factors affect the vegetative growth and plant community.

1.5.Ecological Hierarchy

It includes Species, Population ecology, Community ecology, Biome ecology & Ecosystem.

Species

Species is a group of individuals that are genetically linked with each other. They can interbreed to produce fertile young ones.

Population Ecology

Population is a group of organisms belonging to the same species that live in the same area and interact with one another. Plant and animal populations are not the same in every environment, even when the kinds of organisms in the environment are the same. Population of size may be large or small, depending on such factors as food and water resources. Interactions of the organisms may influence population size. The population ecology is the study of how biotic (living) and abiotic factors (non living), which influence the density, dispersion, and size of population. Population ecology is also concerned with communities. A population ecologist also studies interactions between populations of different species in a community. The population has various group characteristics, which has statistical measures that cannot be applied to individuals. These group characteristics are the three general types. The basic characteristics of a population are its size and density which is affected by four primary population parameters such as Natality (births) mortality (deaths), immigration and emigration.

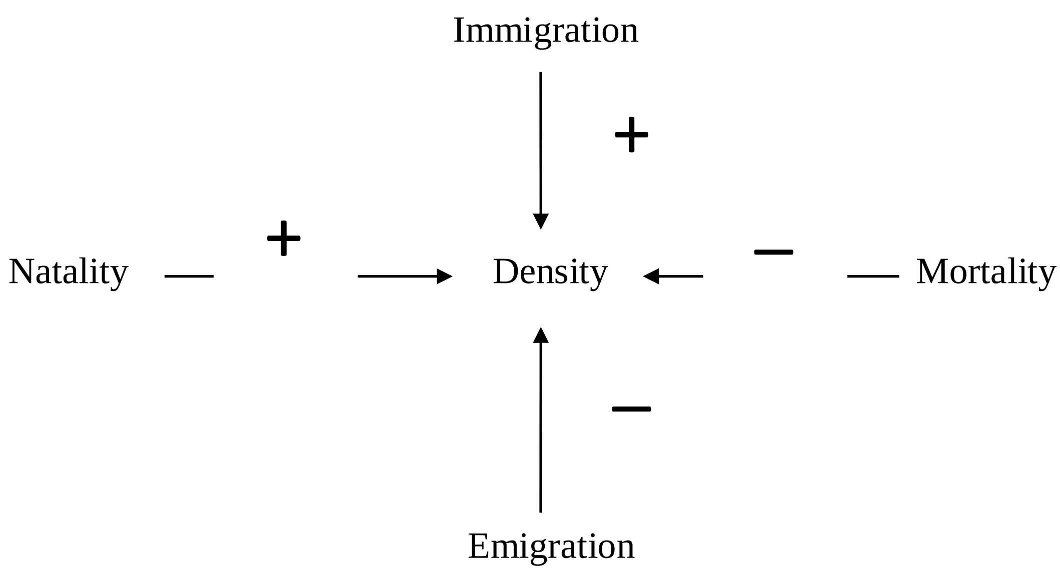

Fig.1.1. Primary population parameters

The secondary characteristics of population, such as its age, distribution, genetic composition and pattern of distribution (distribution of individuals in space) of these population parameters, results from a summation of individual characteristics. Some ecologists recognized following two types of populations.

(1) Mono-specific population-is the population of individuals of only one species.

(2) Mixed or poly-specific population- is the population of individuals of more than one species. Ecologists use the term community for the poly-specific population.

Fig.1.2. Population ecology

Community Ecology

Community is the group of population of different species of plants as well as animals, in a same area. Population of a community interacts with one another. Community is composed of all the biotic factors of an area.

Community ecology examines how interactions among species and their environment affect the abundance distribution and diversity of species within communities. Community ecology is the study of the interactions among a collection of species that inhabit the same geographic area. Community is a larger unit than the population.

Communities may be classified as forests, deserts, grasslands, tundra and so on. Communities may be divided as hydrophytic in pre-dominantly aquatic habitats, mesophytic in moderately moist soils and xerophytic in arid or dry conditions. Communities growing in condition of abundant light are called heliophytic and those growing in shade are called sciophytic. The global community is an enormous mass of life, comprising all the plants and animals in the world. The global community is further divided into continental communities and oceanic communities. Since due to great variability in climatic factors, an exhaustive study in such vast area is practically impossible, therefore, communities are often studied as biotic province.

1.6. Summary

Ecology is the study of the inter-relationship between the living organism with their environment. The term oekologie (ecology) was coined in 1866 by the German biologist. Ernst Haeckel. In 1936, Taylor defined ecology as the science of all the relations of all organisms to all their environments. The term ecosystem was first used in 1935 by A.G. Tansley. The major subdivision of ecology in particular reference to animal ecology and plant ecology. According to other divisions of ecology are autecology and synecology. Autecology also called as population ecology. Synecology also called community ecology. Population is a group of individuals of a particular species (single species), living in a particular ecosystem at a particular time. Community is a group of individuals belonging to different species plants as well as animals. Pyramid of number and pyramid of biomass may be upright or inverted but pyramid of energy is always upright.

1.7.Terminal Question

Q.1. Write short account of basic concepts of ecology?

Answer---

Q.2. Explain the major division of ecology.

Answer---

Q.3. Explain the following?

(i) Population ecology

(ii) Community ecology

Answer---

Q.4. What is ecosystem ecology? Explain the based on levels of organisation ?

Answer---

Q.5. Discuss the Autecology with examples.

Answer---

Q.6. Discuss the Synecology with examples

Answer---

1.8.Further suggested readings

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Unit-2: Autecology

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2.1. Introduction

Autecology is a branch of ecology that focuses on the study of individual organisms and their interactions with their environment. It examines the unique characteristics, adaptations, and behaviours of organisms that allow them to survive, reproduce, and thrive within specific ecological niches. Autecology investigates various aspects of an organism's life, including its morphology, physiology, behaviour, and reproductive strategies. The study of autecology encompasses a wide range of topics. It explores how organisms obtain and utilize resources, such as food, water, and shelter, and how they respond to environmental factors like temperature, humidity, and light. Autecologists investigate the population dynamics of individual species, including their growth rates, density, distribution, and interactions with other organisms.

Autecology also delves into the concept of ecological niches, which refers to the role and position of a species within its ecosystem. It examines how organisms adapt to their specific niches through structural, physiological, and behavioural traits. Understanding an organism's niche is crucial for comprehending its relationships with other species and the functioning of ecological communities. Additionally, autecology examines the responses of organisms to environmental changes, such as habitat loss, climate change, and pollution. It investigates how these factors impact the distribution, abundance, and behaviour of individuals, as well as the conservation and management of species and ecosystems. The field of autecology has both theoretical and applied implications. The knowledge gained from autecological research contributes to our understanding of the fundamental principles that govern the interactions between organisms and their environments. It provides insights into the factors influencing population dynamics, species distributions, and ecosystem functioning. Furthermore, autecology plays a vital role in guiding conservation efforts, environmental management, and the sustainable use of natural resources.

Objectives

- To discuss autecology and its types
- To discuss the characteristics of autecology
- To discuss the population characteristics

2.2. Autecology

Autecology is the study of individual organisms. The approach original focused on the addictiveness of an organism physiology to the environment but has since been expauded to include the study of the distribution and dynamics of population. In terms of biodiversity, autecology has embraced taxonomic diversity. Primarily, physiological ecology is autecology assessing the physiological traits of individual performance. Ecological restoration can be difficult because it requires detailed knowledge of the autecology of an number of species and of the process of succession development. Autecology provides insights into the life history, behaviour, and physiological characteristics of organisms, as well as their role in shaping ecosystems. Autecological studies of desert plants aim to understand their adaptations to arid environments. These plants have developed various mechanisms to cope with limited water availability, such as reduced leaf surface area to minimize water loss through evaporation, deep root systems to access groundwater, and succulent tissues to store water. Alpine Animals: Autecology investigates how animals adapt to harsh conditions in alpine regions, including low temperatures, high altitudes, and limited food resources. For example, the snow leopard is a well-studied alpine species. It has evolved physical adaptations like a thick coat and a long tail for balance, enabling it to survive and hunt in snowy mountainous habitats. The study of interaction between a species and its environment is known as autecology. In autecology, scientist study how a species respond to changes in its environment, and it adopts to its environment. This information can be used to helps protect and conserve species.

The autecology of deep-sea organisms explores how these creatures survive extreme conditions, such as high pressure, darkness, and scarcity of food. Deep-sea fish, like the anglerfish, have developed unique adaptations like bioluminescent lures to attract prey in the darkness of the deep ocean. Autecology examines the characteristics and adaptations of succulent plants, such as cacti and aloevera, which thrive in arid regions. These plants have specialized tissues for water storage, such as the fleshy stems of cacti, allowing them to survive in dry environments. Autecological studies of burrowing animals, such as moles and prairie dogs, focus on their adaptations to living underground. These animals have specialized limbs and strong claws for digging tunnels, which provide shelter from predators and extreme weather conditions. Epiphytic plants, such as orchids and bromeliads, grow on the surface of other plants without harming them. Autecology investigates how these plants obtain water and nutrients from the air and rain, as well as their adaptations to survive in the canopy of forests. Autecology of polar organisms, like polar bears and penguins, explores their adaptations to extremely cold environments. These animals have thick layers of blubber or fat to provide insulation, streamlined bodies for efficient swimming or walking on ice, and specialized behaviours for hunting or finding shelter in icy habitats. The autecology provides valuable information about species ecology. Important for understanding the species distribution and abundance and provide important insights into species conservation.

2.3. Types of Autecology

Autecology encompasses several different types or subfields that focus on specific aspects of individual organisms and their interactions with the environment. There are several types of autecology such as:

- **Behavioural Autecology:** This subfield examines the behaviour of individual organisms and how it relates to their ecological interactions. It looks at the species behaviours and how it interacts with its environment. It looks at the species social behaviour that can important in ecology. It explores topics such as foraging behaviour, mating strategies, territoriality, and communication within a population.
- **Physiological Autecology:** Physiological autecology investigates the physiological characteristics and adaptations of organisms in response to environmental factors. It examines processes like metabolism, respiration, thermoregulation, osmoregulation, and nutrient utilization. This focuses on the species physical characteristics and ability to survive in its environment. It is important in understanding how the species is adopted to its environment and how it responds to environmental change.
- **Life History Autecology:** Life history autecology focuses on the various life stages and reproductive strategies of organisms. It examines aspects such as growth patterns, reproductive timing, reproductive output, survival rates, and the allocation of resources throughout an organism's lifespan.
- **Ecophysiology:** Ecophysiology is a combination of ecology and physiology that studies how an organism's physiology interacts with its environment. It explores the physiological mechanisms that allow organisms to adapt to and respond to environmental variations, such as temperature, light, moisture, and nutrient availability.
- **Population Autecology:** Population autecology investigates the dynamics of populations of a particular species, including factors such as population size, density, distribution, and growth rates. It examines how individuals within a population interact, compete for resources, and respond to changes in their environment.
- **Community Autecology:** Community autecology examines the interactions between different species within a community and how individual organisms contribute to the structure and functioning of the community. It investigates topics such as competition, predation, symbiosis, and the role of individual species in shaping community dynamics.
- **Evolutionary Autecology:** Evolutionary autecology studies how ecological interactions and environmental pressures influence the evolution of individual organisms. It explores the processes of natural selection, adaptation, speciation, and the genetic basis of traits that enhance an organism's fitness in its environment.

These different types of autecology provide a comprehensive understanding of the ecology of individual organisms, from their behaviour and physiology to their life history, population dynamics, and evolutionary processes. By studying these various aspects, scientists can gain insights into how organisms are adapted to their environments and how they contribute to the overall functioning and diversity of ecosystems.

2.4. Population characteristics of autecology

There are several characteristics of autecology

2.4.1. Dispersion

It is the spatial distribution pattern of individuals within a population or a species in a given habitat. It describes how individuals are arranged in relation to one another and provides insights into the social organization, reproductive strategies, and resource utilization of organisms. The dispersion patterns commonly observed in autecology are such as:

- **Clumped Dispersion:** Clumped dispersion occurs when individuals are clustered or aggregated together in groups within a population. This pattern often arises due to the presence of localized resources, such as food, water, or suitable nesting sites. Examples include herds of grazing animals gathering around water sources or trees in a forest or flocks of birds roosting in specific areas with abundant food.
- **Random Dispersion:** Random dispersion is characterized by individuals being distributed without a particular pattern or preference. It occurs when resources are uniformly available across the habitat, and individuals have an equal chance of occupying any given space. Certain plant species with wind-dispersed seeds may exhibit random dispersion as the seeds are dispersed randomly by wind and settle in diverse locations.
- **Regular Dispersion:** Regular dispersion, also known as uniform dispersion, refers to individuals being evenly spaced throughout a habitat. It typically occurs when individuals exhibit territorial behavior, where they actively maintain exclusive territories and keep a specific distance from one another. For example, penguins nesting in colonies often display regular dispersion, with each pair of adults defending their nesting area.
- **Patchy Dispersion:** Patchy dispersion is characterized by the occurrence of distinct patches or clumps of individuals in a habitat, separated by areas with few or no individuals. This

pattern often arises when organisms have specific habitat preferences or specialized resource requirements. For instance, certain insect species may exhibit patchy dispersion around host plants where they lay eggs or feed on specific plant parts.

- **Dispersed Dispersion:** Dispersed dispersion occurs when individuals are distributed at moderate distances from one another without forming distinct groups or clusters. This pattern is often observed in mobile or territorial organisms that maintain some degree of spacing to minimize competition or intraspecific interactions. Wolves, for example, may exhibit dispersed dispersion as they establish and maintain territories within a larger habitat.

2.4.2. Density

It refers the number of individuals of a species per unit area or volume of a habitat. It is a fundamental ecological parameter that provides insights into population dynamics, resource availability, and ecological interactions.

- **High Density:** High density occurs when there are a large number of individuals occupying a relatively small area or volume of habitat. This can happen when resources are abundant, allowing for a higher number of individuals to be supported. For example, in a dense forest, there may be a high density of trees, or in a crowded urban area, there can be a high density of human populations.
- **Low Density:** Low density refers to a small number of individuals spread out over a larger area or volume of habitat. This can occur when resources are scarce or when individuals require large territories to meet their needs. For instance, some large carnivores, such as tigers, require large home ranges, resulting in low population densities in their habitats.
- **Clumped Density:** Clumped density, also known as aggregated density, is characterized by individuals occurring in patches or clusters within a habitat. This pattern often arises due to the distribution of resources, social behaviours, or habitat preferences. For example, herds of grazing animals may exhibit clumped density around areas with abundant vegetation or watering holes.
- **Uniform Density:** Uniform density occurs when individuals are evenly spaced throughout a habitat. This pattern may arise due to territorial behaviors, where individuals actively maintain exclusive territories and keep a specific distance from one another. Some bird

species that defend territories for nesting and feeding may exhibit uniform density within their breeding areas.

- **Random Density:** Random density refers to a pattern where individuals are distributed without a specific pattern or preference. It occurs when resources are uniformly available across the habitat, and individuals have an equal chance of occupying any given space. For instance, some insect species that disperse widely may exhibit random density in their distribution across a habitat.

2.4.3. Natality

Natality, also known as birth or reproduction rate, is an important concept in autecology that refers to the number of offspring produced by individuals or the population of a species within a given time period. It provides insights into the reproductive strategies, population dynamics, and growth potential of organisms.

Examples of natality:

- Many bird species exhibit natality through nesting behaviour. They build nests and lay eggs, resulting in the birth of offspring. For example, robins construct nests in trees or shrubs and lay several eggs that hatch into chicks.
- Mammals often display various natality patterns. For instance, lions reproduce by giving birth to a litter of cubs. Humans, being mammals, have natality in the form of childbirth, where individuals are born as offspring of parents.
- Insects are known for their high natality rates due to their reproductive strategies. For example, ants and bees have specialized castes, including a queen responsible for laying eggs, resulting in the birth of numerous offspring within the colony.
- Many fish species reproduce by spawning, where females release eggs and males fertilize them externally. This leads to the birth of a large number of offspring. Salmon, for instance, migrate to freshwater rivers to spawn and give birth to a large number of young fish
- Natality in plants is often associated with seed production. Plants produce flowers and undergo pollination, leading to the development of seeds. Each seed represents the potential birth of a new individual. For example, sunflowers produce numerous seeds in their flower heads, resulting in the natality of many sunflower plants.

Types of natality:

- **High Natality:** High natality occurs when individuals or populations produce a large number of offspring within a given time period. This can happen when resources are abundant, and environmental conditions are favourable for reproduction. For example, certain small mammals, like mice or rabbits, are known for their high natality rates, with females producing multiple litters per year, each consisting of several offspring.
- **Low Natality:** Low natality refers to a situation where individuals or populations produce a small number of offspring over a given time period. This can occur when resources are limited or when individuals invest more energy and resources into the survival and development of each offspring. Some long-lived organisms, such as elephants, have relatively low natality rates, with females typically giving birth to one calf every few years.
- **Seasonal Natality:** Seasonal natality patterns are observed in many species that reproduce during specific times of the year. This is often influenced by factors such as food availability, temperature, or the timing of optimal conditions for offspring survival. For example, certain bird species may exhibit seasonal natality, laying eggs and raising their young during the spring and summer months when food resources are abundant.
- **Continuous Natality:** Continuous natality occurs when individuals or populations have the ability to reproduce throughout the year, without being restricted to specific seasons. This is commonly observed in species that inhabit stable environments or have access to constant resource availability. Humans are an example of a species with continuous natality, as reproduction can occur at any time of the year.
- **Iteroparity and Semelparity:** Natality patterns can also be classified based on reproductive strategies. Iteroparous species are those that reproduce multiple times over their lifespan, producing offspring in successive breeding seasons. This allows for a more continuous natalityrate. On the other hand, semelparous species are those that reproduce only once in their lifetime, typically investing a significant amount of energy into a single reproductive event. For example, salmon are semelparous species that reproduce once and then die shortly after spawning.

Factor affecting on natality

- The availability of essential resources, such as food, water, nesting sites, and suitable habitat, can have a direct impact on natality.
- Environmental conditions, including temperature, humidity, photoperiod (day length), and climate patterns, can influence natality rates.
- The age and reproductive maturity of individuals play a crucial role in natality rates. The social structure and mating systems within a species can impact natality rates.
- Behavioral and physiological factors, including courtship rituals, mate choice, mating behaviours, and hormonal regulation, can influence natality rates.
- Many species exhibit seasonal breeding patterns linked to specific periods of the year when environmental conditions are favourable for offspring survival.
- Different species employ various reproductive strategies that affect natality rates.
- The presence of predators and predation risk can impact natality rates

2.4.4. Morality

Mortality refers to the death rate or the number of individuals that die within a population or species over a given time period. It is an essential parameter in understanding population dynamics, survival strategies, and the overall health of an organism or population. It represents the rate at which individuals die or the factors that contribute to their death.

Examples of mortality

- Predation is a common cause of mortality in many animal populations. Predators, such as lions, wolves, or eagles, hunt and kill their prey, resulting in the death of individuals within the prey population.
- Diseases and pathogens can cause significant mortality in populations. For example, the spread of a viral or bacterial infection among individuals can result in high mortality rates, as seen in outbreaks of diseases like avian influenza or white-nose syndrome in bats.
- Insufficient access to food resources can lead to mortality in populations. When individuals cannot obtain enough food to meet their energy requirements, they may succumb to starvation. This can occur during periods of food scarcity or due to changes in habitat conditions.
- Environmental factors, such as extreme temperatures, drought, floods, or severe weather events, can cause mortality. For instance, heatwaves can lead to the death of organisms that

are unable to tolerate high temperatures, while severe storms or floods can directly or indirectly result in mortality.

Types of mortality

- **High Mortality:** High mortality occurs when a significant number of individuals within a population die within a specific time frame. This can happen due to various factors, including predation, disease outbreaks, food scarcity, competition, or environmental disturbances. For example, in some insect populations, high mortality rates may be observed due to the prevalence of parasitic wasps or other natural enemies.
- **Low Mortality:** Low mortality refers to a situation where a small number of individuals within a population die within a given time period. This can occur when individuals have effective defense mechanisms, access to abundant resources, or when they are living in a relatively stable and favorable environment. Some long-lived species, such as certain turtles or tortoises, exhibit low mortality rates as they have evolved longevity and resilience against predation and environmental challenges.
- **Age-Specific Mortality:** Age-specific mortality refers to the variation in mortality rates among different age groups within a population. It is common for mortality rates to vary throughout an organism's lifespan. For example, in many bird species, mortality rates are highest during the early stages of life (nestling or fledgling stage) when individuals are more vulnerable to predation, starvation, or harsh weather conditions. Mortality rates may decrease as individuals reach adulthood and acquire better survival skills.
- **Density-Dependent Mortality:** Density-dependent mortality occurs when mortality rates are influenced by the density or abundance of individuals within a population. As population density increases, competition for resources, transmission of diseases, or predation pressures may intensify, resulting in higher mortality rates. For instance, in some rodent populations, increased density can lead to increased disease transmission, leading to higher mortality among individuals.
- **Density-Independent Mortality**: Density-independent mortality refers to mortality rates that are not influenced by population density but are instead driven by external factors such as natural disasters, extreme weather events, or human-induced disturbances. These mortality events can have significant impacts on populations, regardless of their density.

Examples include forest fires, hurricanes, or pollution events that can cause widespread mortality among affected organisms.

Factor effects on mortality

- Predation is a major factor affecting mortality in many populations.
- Diseases and pathogens can cause significant mortality in populations
- Access to sufficient food resources is critical for the survival and well-being of individuals.
- Competition for limited resources, such as food, water, nesting sites, or mates, can affect mortality rates.
- The quality of the habitat plays a vital role in mortality rates.
- Environmental factors such as temperature, precipitation, extreme weather events, and natural disasters can significantly impact mortality.
- Human activities have a considerable impact on mortality in many populations.
- Mortality rates often vary among different age groups and life stages within a population.

2.4.5. Age

Age is an important factor in autecology as it plays a significant role in the life history and ecology of individuals and populations. Age refers to the chronological or physiological stage of an organism's life cycle. Understanding the age structure and age-related dynamics within populations provides insights into various ecological processes.

- **Age Structure:** Age structure refers to the distribution of individuals across different age groups within a population. It provides information about the relative proportions of individuals at different life stages, such as juveniles, sub-adults, and adults. Age structure influences population dynamics, reproductive potential, and the capacity for population growth or decline.
- **Life History Traits:** Age is closely tied to life history traits, which are characteristics that influence an organism's survival, reproduction, and overall fitness. Life history traits include age at maturity, reproductive output, lifespan, senescence, and investment in offspring. Different species exhibit variations in life history traits based on their specific ecological strategies and environmental conditions.

- **Survival and Mortality:** Age influences survival rates and mortality patterns within populations. Juveniles and individuals at early life stages often experience higher mortality rates due to factors such as predation, competition, or vulnerability. Mortality rates may decrease in adults, but can increase again in older individuals due to senescence and age-related decline.
- **Reproductive Output:** Age is closely linked to reproductive output. Many organisms experience delayed reproductive maturity, requiring a certain age or size before they can successfully reproduce. Reproductive output can vary with age, with individuals typically exhibiting peak reproductive performance during their prime reproductive years.
- **Population Growth and Dynamics:** The age structure of a population influences its growth and dynamics. The presence of a large proportion of juveniles may indicate high natality rates and potential population growth, while an aging population with a large proportion of older individuals may indicate declining natality rates and decreased population growth potential.
- **Resource Allocation:** Age affects resource allocation strategies within individuals. Younger individuals often allocate more resources towards growth and development, while older individuals may allocate more resources towards reproduction or survival. Resource allocation patterns can impact an individual's fitness and overall success.
- **Senescence:** Senescence refers to the gradual deterioration of physiological function and increased vulnerability to mortality as individual's age. Senescence can lead to decreased survival rates, reduced reproductive output, and an increased risk of age-related diseases or disorders.
- **Population Demographics:** Age is a critical component of population demographics. Studying age-related patterns and changes in age structure over time can provide insights into population trends, such as population aging, population decline, or population recovery.

2.4.6. Structure

In autecology, the focus is on the study of individual organisms and their relationship with their environment. The term "structure" in autecology refers to the various physical and physiological characteristics of an organism that influence its interactions with its environment.

- **Morphological Structure:** Morphological structure refers to the physical characteristics and form of an organism. This includes its size, shape, coloration, body parts, and adaptations for specific functions. For example, the long neck of a giraffe allows it to reach high tree leaves, while the sharp claws of a bird of prey aid in capturing prey.

- **Anatomical Structure:** Anatomical structure refers to the internal organization and arrangement of an organism's tissues and organs. This includes features such as organ systems, skeletal structures, and specialized organs. For instance, the streamlined body shape and the presence of gills in fish are anatomical adaptations for aquatic life.
- **Physiological Structure:** Physiological structure refers to the internal functions and processes of an organism. This includes metabolic rates, respiration, digestion, reproduction, and sensory capabilities. For example, the ability of certain animals to hibernate during harsh winters is a physiological adaptation that helps conserve energy.
- **Reproductive Structure:** Reproductive structure relates to the specific adaptations and characteristics involved in an organism's reproductive process. This includes reproductive organs, mating behaviors, and strategies for producing and dispersing offspring. Examples include the flowers of plants, the courtship displays of birds, or the breeding behavior of mammals.
- **Behavioral Structure**: Behavioral structure refers to the patterns of behavior exhibited by an organism in response to its environment. This includes feeding habits, movement patterns, communication signals, and social behaviors. For instance, the migration behavior of birds or the burrowing behavior of certain mammals are examples of behavioral structures.
- **Ecological Niche Structure:** The ecological niche of an organism encompasses its interactions with both biotic and abiotic factors in its environment. It includes the resources it uses, its position in the food web, and its tolerance to environmental conditions. The structure of an organism's ecological niche influences its distribution, abundance, and interactions with other species.

2.4.7. Population growth

Population growth is a fundamental concept in autecology that focuses on the study of how populations of individual organisms change over time. It examines the factors that influence population size, density, and distribution. Here are some examples of population growth patterns in autecology:

Exponential Growth: Exponential growth occurs when a population increases at an accelerating rate under ideal conditions with unlimited resources. In this pattern, the population size doubles at a constant rate over a given time period. For example, bacteria in a nutrient-rich laboratory culture or invasive species in a new environment may exhibit exponential growth until resource limits or other factors constrain their growth.

Logistic Growth: Logistic growth occurs when a population initially grows exponentially but eventually levels off due to environmental constraints. As resources become limited, the growth rate slows, and the population approaches its carrying capacity, which is the maximum population size that the environment can sustain. For example, a population of deer in a forest may experience logistic growth as they reach the carrying capacity determined by available food and habitat resources.

Boom-and-Bust Cycles: Some populations exhibit boom-and-bust cycles, characterized by periodic fluctuations in population size. These cycles alternate between rapid population growth and sharp declines. For example, lemmings in the Arctic experience population booms followed by crashes due to changes in food availability and predator-prey dynamics.

Density-Dependent Regulation: Density-dependent factors influence population growth rates in response to population density. These factors can include competition for resources, predation, disease, and territoriality. As population density increases, these factors become more pronounced, leading to reduced birth rates, increased mortality, or dispersal. For example, in some bird species, increased population density can lead to decreased nesting success and reduced reproduction due to competition for nesting sites and food.

Density-Independent Regulation: Density-independent factors affect population growth irrespective of population density. These factors can include natural disasters, extreme weather events, or human activities. Unlike density-dependent factors, they do not vary with population size. For example, a wildfire that destroys the habitat of a population of small mammals can result in a sudden decline in their population size, regardless of their initial density.

Life History Strategies: Different species exhibit various life history strategies, which influence population growth. Some species have a high reproductive rate, producing many offspring with lower chances of survival, while others have a lower reproductive rate but invest more resources in each offspring, increasing their chances of survival. These strategies shape population growth patterns. For example, r-selected species such as insects and weeds are characterized by rapid population growth and early reproduction, while K-selected species such as elephants and whales have slower population growth rates and longer lifespans.

2.4.8. Human population and growth

Human population growth is a significant aspect of autecology as it explores the relationship between human populations and their environment. Understanding the dynamics of human population growth helps in examining the impact of human activities on ecosystems and the sustainability of resources. Here are some examples related to human population growth in autecology:

- **Exponential Growth**: Human population growth has exhibited exponential growth patterns over the past few centuries. The global population has increased dramatically, particularly since the Industrial Revolution. Advances in medicine, sanitation, and agriculture have resulted in reduced mortality rates and increased life expectancy, leading to exponential population growth.
- **Carrying Capacity:** The concept of carrying capacity is relevant to human population growth. Earth has finite resources, and the human population's growth is limited by the planet's carrying capacity—the maximum number of individuals that can be sustained by available resources. Human activities, such as deforestation, pollution, and overconsumption, can strain the carrying capacity of ecosystems and negatively impact biodiversity and environmental health.
- **Urbanization:** The process of urbanization is closely tied to human population growth. As more people migrate from rural areas to cities, urban populations grow rapidly. Urbanization affects ecological systems, leading to habitat loss, fragmentation, and increased energy and resource consumption. The expansion of urban areas can have significant environmental consequences.
- **Resource Depletion**: The growing human population puts pressure on natural resources, including water, arable land, energy, and minerals. The increased demand for resources has led to overexploitation, depletion, and degradation of ecosystems. For example, overfishing has depleted fish populations, deforestation has diminished forest cover, and excessive water extraction has led to water scarcity in certain regions.

- **Pollution and Waste:** The rapid growth of the human population has resulted in increased pollution and waste generation. Industrial activities, transportation, and the use of fossil fuels contribute to air and water pollution, leading to detrimental effects on ecosystems and human health. Improper waste management can also lead to contamination of land, water bodies, and habitats.
- **Environmental Impacts:** Human population growth has various environmental impacts, including habitat destruction, biodiversity loss, climate change, and the alteration of natural ecosystems. Deforestation, land conversion for agriculture, and urban expansion contribute to habitat destruction and fragmentation, threatening many species. Increased greenhouse gas emissions from human activities contribute to climate change, which has wide-ranging ecological consequences.
- **Sustainable Development:** The concept of sustainable development aims to balance human needs with environmental conservation. It emphasizes the importance of maintaining ecological integrity, conserving resources, and reducing the ecological footprint of human activities. Sustainable practices promote the long-term well-being of both human populations and ecosystems.

2.5. Ecological niche and habitat

Ecological niche

Ecological niche refers to the unique functional role and position of a species in its habitat or ecosystem. Niche play essential role in the conservation of organisms. If we must conserve species in their native habitat these should know the nature requirements of the species. In nature many species occupy the same habitat but they perform different functions.

1. Habitat niche -where it lives
2. Food Niche -what it eats or decomposes and what species it completes with,
3. Reproductive niche - how and when it reproduce
4. Physical and chemical niche-temperature and land scope, land slope, humidity and other requirement.

Habitat

Habitat is the physical environment in which an organism in brackets addresses of an organism. Many habitat together makeup environments. A single habitat mean common for multiple organised which have similar requirements. For example a single aquatic habitat mean support a fish frog traps phytoplanktons and many others. The various species sharing a habitat does hype the same address example forest Lake etc.

Difference between rich and habitat

Danish of species is like its address. In contrast niche can be considered its lifestyle and profession (I.e. activities and responses specific to the species).

A niche is unique for a species; while many species share the habitat no two species in a habitat. No two species in a habitat can have the same niche. This is because of the competition with one another until one is displaced. For example many different species of insects maybe pests of the same plant but they can co exist as they feet on different parts of the same plant.

2.6. Summary

. In summary, autecology is a branch of ecology that focuses on the study of individual organisms and their relationships with their environment. By examining the unique characteristics, adaptations, and behaviours of organisms, autecology provides insights into the dynamics of populations, the functioning of ecosystems, and the conservation of biodiversity. Autecology examines the characteristics and adaptations of succulent plants, such as cacti and aloevera, which thrive in arid regions. These plants have specialized tissues for water storage, such as the fleshy stems of cacti, allowing them to survive in dry environments. Autecological studies of burrowing animals, such as moles and prairie dogs, focus on their adaptations to living underground. Human population growth has various environmental impacts, including habitat destruction, biodiversity loss, climate change, and the alteration of natural ecosystems.

2.7. Terminal questions

Q.1. What is the autecology? Discuss different types of autecology.

Answer:--

Q.2. What is the Population characteristic in autecology?

Answer:--

Q.3. Discuss the dispersion and its characteristics in autecology.

Answer:--

Q.4. Discuss the ecological niche and habitat

Answer:--

Q.5. What do you means about natality?

Answer:--

Q.6. What do you means about morality?

Answer:--

Q.7. Discuss the age, structure and population growth in autecology.

Answer:--

2.8. Further suggested readings

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Unit-3: Synecology

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3.1. Introduction

Synecology is the ecology of relationships among organisms and populations which is mostly concerned with communication of material energy and information of the entire system of components. System ecology therefore, is the implementation of Synecology. In this manner the dimensional units used in ecosystem studies are usually the amount of energy or matter moving through the system. This differs from population and community ecology, studies in which the dimensional units are typically the number of individuals. Synecology, also known as community ecology, is a branch of ecology that focuses on the study of interactions among different species within a particular ecological community. It seeks to understand the patterns, dynamics, and processes that shape the structure and function of these communities. In essence, synecology explores how different species coexist and interact with one another and their environment. At the core of synecology is the concept of ecological communities, which consist of multiple species living together in a defined area and interacting through various ecological relationships. These relationships can be classified into different types, such as predation, competition, mutualism, commensalism, and parasitism, among others. Synecologists aim to study the complexity and intricacy of these relationships and their effects on the overall community dynamics. It also encompasses the research on community dynamics, population ecology, and the effects of human activities on ecological communities. A human-induced disturbance, such as habitat destruction, pollution, and climate change, has significantly impact on the community structure and function that lead to the loss of biodiversity and ecological imbalances.

Synecology is also characterized by focusing on ecological communities such as the study of interactions among species, the exploration of ecological relationships, the examination of species diversity, the integration of abiotic factors, the use of multiple research approaches, and its application to conservation and management. These characteristics contribute to our understanding of the complexities of ecological communities and their importance for maintaining biodiversity and ecosystem stability.Understanding community structure provides insights into the organization and functioning of ecological communities. It helps in comprehending species interactions, population dynamics, ecosystem processes, and the responses of communities to environmental changes. By studying community structure, synecologists can gain a deeper understanding of the mechanisms that maintain biodiversity, shape ecosystem functioning, and inform conservation and management efforts.

Objectives

- To discuss the growth of population
- To discuss the ecotone and ecotype
- To discuss the ecological indicators
- To discuss the ecological succession

3.2. Synecology Overview:

As we know that the Synecology is community ecology that deals the study of ecological communities and their interactions between species within the communities. It explores the intricate web of relationships among organisms, their physical environment, and the processes that shape their interactions. In addition, the synecology also seeks to understand that how different species coexist and interact in a given habitat or ecosystem. It examines the various factors that influence community structure, such as species diversity, abundance, and distribution patterns. By studying these aspects, synecologists aim to unravel the complexities of ecological communities and shed light on the mechanisms that maintain biodiversity.One of the fundamental concepts in synecology is the idea of ecological niche. A niche refers to the specific role and requirements of a species within its community. Each species has its own unique niche, which includes its resource use, habitat preferences, and interactions with other species. Understanding these niches is crucial for comprehending the dynamics of community assembly and the coexistence of multiple species. However, the synecology also investigates the relationships between organisms, ranging from symbiotic interactions to predator-prey relationships. Mutualistic interactions, where two species benefit from each other, and competitive interactions, where multiple species compete for limited resources, are common areas of study. Additionally, synecology explores the intricate food webs that connect species together and trace the flow of energy and matter through ecosystems.Furthermore; synecology recognizes the importance of abiotic factors in shaping communities. Physical factors such as temperature, precipitation, soil composition, and topography influence the distribution and abundance of species within a habitat. These abiotic factors interact with biotic factors, such as competition and predation, to determine the composition and structure of communities.Synecology employs a range of research techniques and methodologies to study ecological communities. Field surveys, experimental manipulations, and mathematical models are commonly used to gather data and test ecological hypotheses. These approaches allow synecologists to explore patterns and processes at different spatial and temporal scales, from individual organisms to entire ecosystems.

The knowledge generated by synecology has important implications for conservation and management of natural resources. By understanding the intricate relationships between species and their environment, scientists can better predict the impacts of human activities on ecological communities and develop strategies to mitigate those effects.

3.3. Growth form

Growth in synecology refers to the increase in population size or biomass of species within an ecological community over time. It is an important aspect to understand as it influences the dynamics, interactions, and structure of communities. Some types of growth observed in synecology are such as:

Population Growth: Population growth refers to increase in the number of individuals of a particular species within a community. It is influenced by birth rates, death rates, immigration, and emigration. For example, in a bird community, a species of migratory birds may experience population growth during the breeding season as individuals return to the community to reproduce.

Biomass Growth: Biomass growth pertains to the increase in the total mass or weight of living organisms within a community. It reflects the collective growth of all the individuals in the community. For instance, in a forest community, the biomass may increase over time as trees grow larger and new trees establish themselves. Biomass growth is influenced by factors such as primary productivity (photosynthesis), nutrient availability, disturbance events, and interspecific interactions.

Successional Growth: Successional growth refers to the changes in species composition and community structure over time in a process known as ecological succession. It occurs in habitats that have been disturbed or are undergoing environmental changes. For example, after a forest fire, the community may undergo successional growth as pioneer plant species colonize the area, followed by intermediate species, and eventually leading to a mature forest community.

Mutualistic Growth: Mutualistic growth involves the increase in population sizes or biomass of two or more species that engage in mutualistic interactions. Mutualism is a type of symbiotic relationship where both species benefit from the interaction. For example, in a pollination mutualism, flowering plants and their pollinators (e.g., bees, butterflies) experience mutualistic growth as they depend on each other for reproduction and resource exchange. The partner availability, resource availability influenced the mutualistic growth. **Community-level Growth**: Community-level growth refers to the overall increase in the size or complexity of an ecological community over time. It encompasses the growth of multiple species and the interactions among them. For instance, in a coral reef community, the community-level growth may occur through the establishment and growth of coral colonies, the recruitment of new fish species, and the development of complex trophic interactions. Community-level growth is influenced by factors such as species interactions, environmental conditions, and the availability of suitable habitats.

3.4. Keystone species

Keystone species play a critical role in maintaining the structure and functioning of ecosystems. They have a disproportionate impact on their environment relative to their abundance or biomass. The removal or decline of a keystone species can lead to significant changes in community dynamics and ecosystem health. Some examples of keystone species:

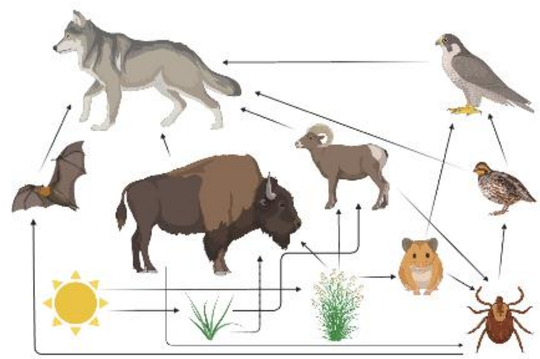

Fig. 3.1: Keystone species

Sea Otters (*Enhydralutris*): Sea otters are considered a keystone species in kelp forest ecosystems. They prey on sea urchins, which are herbivores that feed on kelp. By keeping sea urchin populations in check, sea otters prevent overgrazing of kelp forests. This allows the kelp to thrive and provides habitat for a diverse array of marine species. When sea otters were severely depleted due to fur trade in the past, it led to the collapse of kelp forests and cascading effects throughout the ecosystem.

African Elephants (*Loxodonta africana*): African elephants are keystone species in savanna ecosystems. They create and maintain open grasslands through their feeding habits and trampling. Their browsing activities prevent woody plant encroachment and promote the growth of grasses. The open grasslands created by elephants provide habitat for a variety of species, influence nutrient cycling, and shape of the landscape. The decline of elephant populations due to poaching and habitat loss has resulted in changes to savanna ecosystems.

Gray Wolves (*Canis lupus*): Gray wolves are considered keystone species in various ecosystems, including forests and tundra. They regulate prey populations, such as deer and elk, through predation. By controlling herbivore numbers, wolves prevent overgrazing of vegetation and shape the structure of plant communities. Their presence can also indirectly benefit other species, such as scavengers that rely on wolf-killed prey. When wolves were extirpated from certain areas, it had cascading effects on prey populations and ecosystem dynamics.

Prairie Dogs (*Cynomys spp*.): Prairie dogs are keystone species in grassland ecosystems of North America. They are highly social rodents that create complex burrow systems. These burrows provide habitat for a variety of other species, including reptiles, insects, and small mammals. The grazing and clipping behavior of prairie dogs also influences the composition and structure of plant communities. Their activities increase plant diversity and nutrient cycling. The decline of prairie dog populations due to habitat loss and eradication efforts has had negative impacts on grassland ecosystems.

Coral Reefs: Coral reefs can be considered keystone ecosystems themselves, as they support high biodiversity and provide numerous ecosystem services. Corals, along with the symbiotic algae (zooxanthellae) they host, are the primary builders of reef structures. They create the framework that supports a diverse array of marine species. Corals provide shelter, food, and breeding grounds for many organisms. The decline of coral reefs due to factors like climate change, pollution, and overfishing has far-reaching consequences for the health and biodiversity of associated ecosystems.

3.5. Ecotone

An ecotone refers to a transitional zone or boundary where two different ecosystems or habitats meet. It is characterized by a mixture or blending of species and ecological characteristics from both adjacent ecosystems. Ecotones can occur between various habitat types, such as forest and grassland, freshwater and marine, or wetland and upland. They often exhibit unique ecological conditions, species assemblages, and ecological processes that differ from those found within the adjacent ecosystems. Examples of ecotones include the mangrove forest and marine interface, where mangrove trees grow at the boundary between land and sea, or the edge between a meadow and a forest.

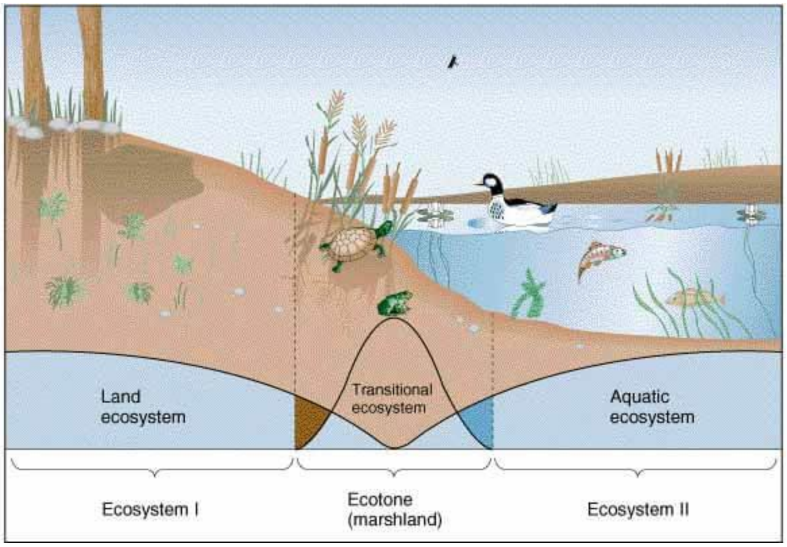

Fig.3.2: Ecotone

An ecotone is a zone of junction are a transition area between two byoms it is the zone where to communities meet and integrate for example the mangrove forest represent and ecotone between Marine and terrestrial ecosystems.

Other examples are grassland between (forest and desert), estuaries (between fresh water and salt water), and riverbank or marshland (between dry and wet).

Characteristics of an ecotone

An ecotone may be narrow (between grassland and forest) are wide (between forest and desert). It has conditions intermediate to the adjacent ecosystems. Hence; it is a zone of tension.Usually the number and the population density of the species of our going community decrease as we move away from the community or ecosystem. A well developed ecotone contains some organism which is entirely different from that of the adjoining communities. Ecotone region like mangroves wetlands, estuaries, grassland etc. It has for greater productivity then natural ecosystem like a forest ecosystem, Ocean ecosystem, pond ecosystem, riverine ecosystem and desert ecosystem etc. This is because of the wide ranging species from the adjacent ecosystem being present in the ecotone

3.6. Ecotype

An ecotype refers to a distinct population or group of individuals within a species that has adapted to a specific ecological niche or habitat. Ecotypes arise due to local environmental conditions and selective pressures, resulting in differences in traits, behaviour, or physiological adaptations compared to other populations of the same species. These differences allow ecotypes to be better suited to their specific environment. Ecotypes can be observed in various organisms, including plants, animals, and microorganisms. For example, in the plant species Salix herbacea (dwarf willow), different ecotypes have evolved in response to different altitudes and climatic conditions. Each ecotype exhibits distinct growth patterns, leaf morphology, and reproductive strategies specific to their respective altitudinal ranges.

Fig.3.3: distinct population or group of individuals within a species

3.7.Ecoline

Ecoline is a term that is commonly used to describe a range of products or services that are designed to be environmentally friendly or have a reduced impact on the environment. The term "ecoline" is a combination of the words "eco" (short for ecological or environmentally friendly) and "line" (indicating a product line or range). The concept of ecoline reflects the growing awareness and concern for environmental issues and the desire to make more sustainable choices. Consumers are increasingly seeking out products and services that align with their values and contribute to a more sustainable future. As a result, many companies are adopting ecoline strategies to meet this demand and reduce their environmental impact. Ecoline is a zone of gradual but continues change from one ecosystem to another when there is no sharp boundary between the two in terms of species composition. It occurs across the environment gradient (gradual change in abiotic factor such as altitude, temperature, salinity, depth etc.Ecoline products or services typically prioritize sustainability and aim to minimize their carbon footprint, energy consumption, and waste generation. They often incorporate features such as recycled materials, renewable energy sources, energy-efficient technologies, and reduced packaging. Ecoline products can be found in various industries, including household goods, clothing, food and beverages, transportation, and more.

3.8. Ecological indicators

Ecological indicators in synecology are measurements or variables used to assess the ecological condition, health, and functioning of ecosystems. They provide quantitative or qualitative information about specific aspects of the environment and the responses of organisms within a community.

Species Richness: Species richness is a commonly used indicator that quantifies the number of different species present in a community or ecosystem. It provides information about the diversity and variety of organisms within an area. Higher species richness generally indicates a healthier and more resilient ecosystem.

Species Diversity: Species diversity incorporates both species richness and the evenness of species abundance in a community. It provides a measure of the distribution and balance of species within an ecosystem. High species diversity is often associated with more stable and functioning ecosystems.

Biomass: Biomass is the total mass of living organisms present in a given area or community. It can be used as an indicator of the overall productivity and energy flow within an ecosystem. Changes in biomass can indicate shifts in ecological processes or disturbance regimes.

Endemic Species: Endemic species are those that are found only in a specific geographic region and are not naturally found anywhere else. The presence of endemic species indicates unique and localized ecological conditions. Monitoring the status of endemic species can help assess the health and conservation value of an ecosystem.

Indicator Species: Indicator species are species that are particularly sensitive to specific environmental conditions or changes. Their presence or absence can indicate the overall ecological condition of an ecosystem. For example, the presence of certain macroinvertebrate species in freshwater systems can be used as indicators of water quality and pollution levels.

Habitat Structure: The structure and composition of habitats can serve as indicators of ecosystem health and functioning. This includes aspects such as vegetation cover, habitat complexity, and landscape connectivity. Changes in habitat structure can affect species interactions, resource availability, and overall community dynamics.

Nutrient Cycling: Assessing nutrient cycling processes, such as the availability and cycling of carbon, nitrogen, and phosphorus, can provide insights into ecosystem productivity and nutrient dynamics. Imbalances or disruptions in nutrient cycling can indicate disturbances or alterations in ecosystem functioning.

3.9. Ecological succession

Ecological succession is the process of gradual and predictable change in the structure and composition of a community over time. It occurs in ecosystems following a disturbance or the establishment of a new habitat.

Causes of Succession:

A succession always starts on a bare area which may be sand, clay-gravel, rock and water. The causes like physiographic processes, climatic factors and biotic agents are responsible for plant succession.

A number of causes induce together the process of succession which is as follows:

1. **Physiographic processes**:

It mostly occurs in primary bare areas as-

(a) Erosion- by water, wind, gravity or glaciers.

(b) Deposition- by water, wind, gravity, glaciers, volcanoes.

(c) Ecesis- The soil condition is also changing by the process of invasion, migration, competition and reaction of the population.

2. **Climatic factors:** It includes temperature, rainfall, light intensity, gaseous composition, wind etc. The climatic factors mostly produce secondry bare are:

(a) Wind- It eliminates the previous vegetation.

(b) Drought- It results in drying and killing of weaker species.

(c) Snow- It kills the previous vegetation.

(d) Lightning- It causes fire in the forest.

3. Biotic agents: Producing mostly secondary bare areas :

(a) Man - Destroying natural vegetation.

(b) Animals- By overgrazing.

(c) Bacteria, Fungi, Insects- Eliminates species by disease or grazing.

4. **Stabilizing Causes:** Succession is taking place in order to attain the climax stage. Wind, water, glacier etc. brought soil erosion resulting in open bare land where plant succession can take place.

High velocity winds uproot trees and sometimes destroy even climax vegetation. This causes a fresh succession of plant communities. Similarly drought, snow and fire results in open bare land for plant succession.

In a community, there is competition amongst different members for their existence. In such a process, some of the members are not found suitable and thus are gradually replaced by new one.

Process of ecological succession:

The succession involves successive colonization of a bare area by different plant communities in course of time. The process of succession is completed through the following sequential steps:

- Nudation
- Invasion
- Competition and Coaction.
- Reaction
- Stabilization (Climax)

1 **Nudation -** This is the development of bare area without any life form. Volcanic eruption, landslide, flooding, erosion, fire, disease etc. destroy the life completely and make the area bare. The succession starts in the bare area.

2 **Invasion-** It is arrival of propagules of various organisms and their establishment in the new area. Invasion includes the following three steps.

i. **Migration-** Seeds, propagules and spores of the species are brought to new area by the agency of air, water and animals. This is called migration.

ii. **Ecesis (Establishment) -** The successful establishment of species in the new area is known as Ecesis. After migration the seed or propagules germinate, grow into seedlings and adults start to reproduce.

iii. **Aggregation-** It includes multiplication and aggregation of organism in a large population in the area.

3. **Competition and Co-action-** The aggregation of individuals in an area leads to interspecific and intraspecific competition. The competition is for water, nutrients, heat, light, Co_2, O_2 and space. The intraspecific competition is more acute than interspecific competition because the needs of the individuals of the same species are very much similar. Individuals of a species affect each other's life in various ways and this is called co-action.

4. **Reaction-** The interaction and reaction among plant species as well as between habitat changes the soil, water, temperature, light etc. of the environment. As a result the environment is modified and less suited for the existing community which sooner or later is replaced by another community (Seral community). The whole sequence of communities that replaces on another in the given area is called a **Sere** and different communities constituting the sere are called seral communities.

5. **Stabilization (Climax)**: At last a final or terminal community is established. These are stabilized for a longer period of time and maintain equilibrium with the environment of that area. This final community is not replaced and is known as climax community and the stage as climax stage.

Types of ecological succession

Ecological succession can be divided into two main types: primary succession and secondary succession.

Primary Succession

Primary succession begins on these barren surfaces with no pre-existing soil. During primary succession, organisms must start from scratch. First, lichens might attach themselves to rocks, and a few small plants able to live without much soil might appear. These are known as "pioneer species."Mosses and lichens are the first organisms to colonize the rocks, breaking them down and creating soil. As soil depth increases, other plant species, such as grasses and wildflowers, establish themselves. Over time, shrubs and trees become dominant, leading to the development of a forested ecosystem. Over time, pioneer species such as lichens and mosses colonize the volcanic rock, breaking it down and facilitating soil formation. These early colonizers are followed by herbaceous plants, shrubs, and eventually, trees. The process continues until a mature forest community is established. If the site is disturbed after this point, secondary succession occurs.\

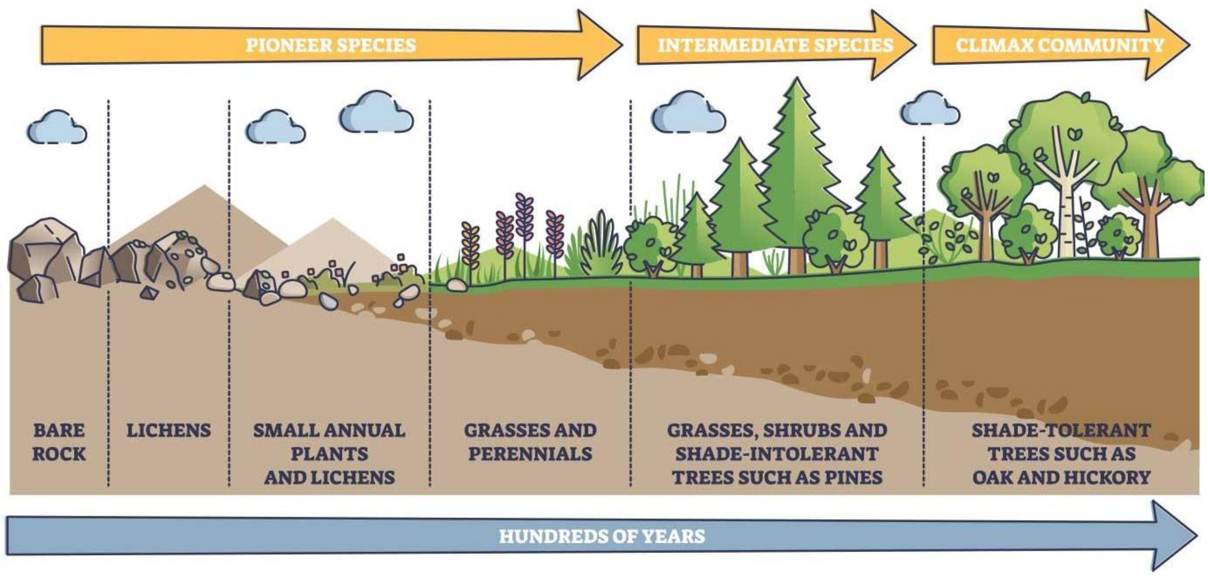

Fig.3.4: Primary ecological succession

Secondary Succession

Secondary succession takes place as the ecosystem recovers. Herbaceous plants and grasses quickly colonize the burned area due to their ability to regenerate from seeds and rhizomes. These early successional species help stabilize the soil and provide favorable conditions for the establishment of shrubs and tree seedlings. Over time, the community transitions back to a mature forest, with the original species composition gradually re-established. These species improve soil fertility and structure, facilitating the establishment of perennial plants. Eventually, shrubs and trees may become established, leading to the re-establishment of a more diverse and complex ecosystem. For example, after a forest fire that kills all the mature trees on a particular landscape, grasses might grow, followed by shrubs and a variety of tree species, until eventually the community that existed before the fire is present again.

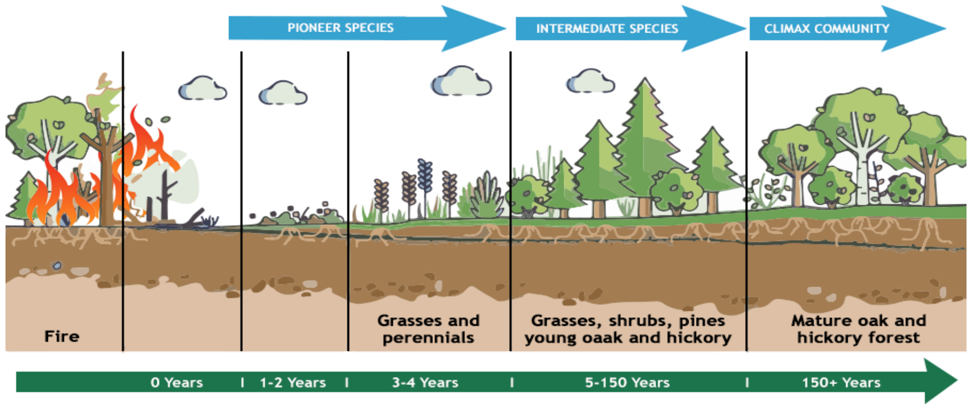

Fig.3.5: Primary ecological succession

Climax community

A climax community is the “endpoint” of succession within the context of a particular climate and geography. Climax community or climatic climax community is a historic term for a community of plants, animals, and fungi which, through the process of ecological succession in the development of vegetation in an area over time, have reached a steady state. This equilibrium was thought to occur because the climax community is composed of species best adapted to average conditions in that area. The term is sometimes also applied in soil development. Nevertheless, it has been found that a "steady state" is more apparent than real, particularly across long timescales. Notwithstanding, it remains a useful concept. The idea of a single climax, which is defined in relation to regional climate, originated with Frederic Clements in the early 1900s. The first analysis of succession as leading to something like a climax was written by Henry Cowles in 1899, but it was Clements who used the term "climax" to describe the idealized endpoint of succession. A climax community will persist in a given location until a disturbance occurs.

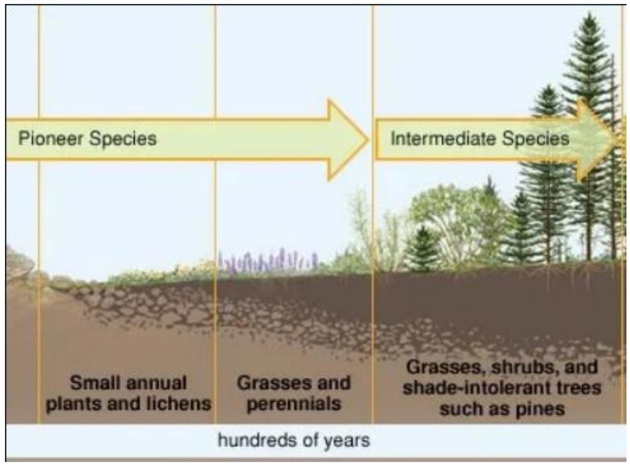

Fig.3.6: Climax stage of community

Hydrosere- Succession in water

A hydrosere is a plant succession which occurs in freshly built deep reservoir or any other new water body. Aquatic succession is a series of stages involving the gradual infilling of a shallow lake or pond with sediments. It is composed of 7 stages: (1) phytoplankton stage; (2) rooted submerged stage; (3) floating stage; (4) reed-swamp stage; (5) sedge-meadow stage; (6) woodland stage; and (7) climax stage.

a. **Phytoplankton stage-** In the initial stage blue green algae, green algae (*Spirogyra*, *Oedogonium*) are the pioneer colonizers. If traces of phosphorous is present blooms of blue green algae appears. These are consumed by zooplankton (*Amoeba*, *Euglena*, *Paramecium* etc) and fish (sun fish, blue gillfish etc). Gradually this organism dies and increases the content of dead organic matter in the pond.

b. **Rooted submerged stage -** The above algae add large quantities of organic matter and nutrient in the pond. Thus the pond becomes lined with soft mud which is a suitable substratum for the growth of rooted submerged plants. The plants like *Hydrilla*, *Utricularia*, *Vallisneria* etc. appear there. The seeds of these plants are brought by birds and animals which frequently visit the water bodies. The reduced depth of water and rich substratum favours colonisation of floating plants.

c. **Floating stage (Rooted and free-floating)-** When the water depth is about 2-8 feet, the rooted floating plants such as *Nymphaea, Ranunculus, Trapa* etc. grow there. Many free floating species like *Pistia, Azolla, Lemna, Wolffia, Eicchornia* etc also grow there. floating species migrate inwards, giving way to the swamp plants.

d. **Reed swamp stage (Amphibious stage)-** In shallow water (upto 2 feet depth) the plants like *Typha, Pontederia, Sagittaria, Carex, Mariscus* etc. grow. These plants are slightly submerged and rooted by large much branched rhizomes. The vegetation is very dense therefore, it helps in accumulating sedimentary materials and plant remains.

e. **Sedge-meadow stage (Marginal mats)-** The filling process finally results in a marshy soil which may be too dry for the plants of pre-existing community. The plants of the sedge-meadow stage, therefore, gradually disappear and make way for helophytic vegetation depending upon the nature of the climate.

f. **Woodland stage-** Species of shrubs eg. *Salix, Cephalanthus, Cornus* etc. and woody plants eg. *Alnus, Populus* etc grow in this stage. These plants can tolerate waterlogged conditions..

g. **Climax forests -** The nature of the climax depends upon the climate of the region. In tropical region dense rain forest develops due to high rainfall. In the temperate region mixed forest develops and in the region of moderate rainfall deciduous forest develops as climax. (Fig. 3.2)

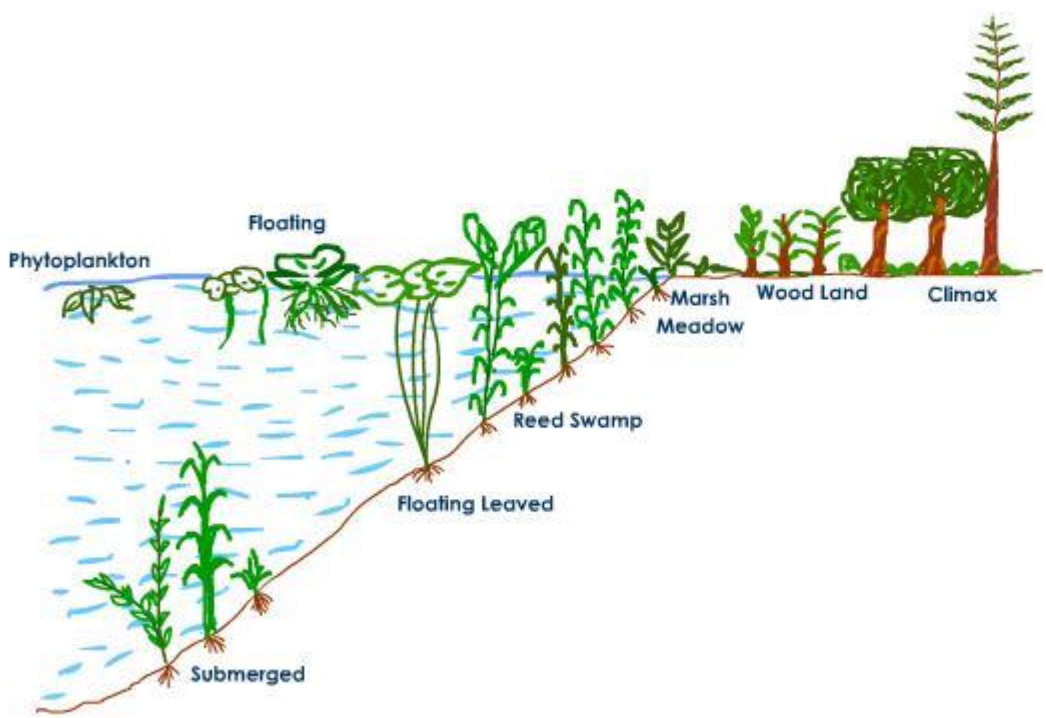

Fig.3.7: Different Hydrosere succession stage in water

3.10. Summary

One fundamental aspect of synecology is the study of species diversity and its ecological significance. Researchers examine species richness (the number of species) and species evenness (the distribution of individuals among species) within a community. High species diversity is generally associated with increased stability, resilience, and productivity of ecosystems.Ecotones represent transitional zones between two different ecosystems, characterized by a mix of species and ecological characteristics. Ecotypes, on the other hand, are distinct populations within a species that have adapted to specific local environmental conditions. Both concepts highlight the dynamic nature of ecological boundaries and the diverse adaptations observed in nature.Synecologists also investigate ecological succession, which refers to the predictable changes in community composition and structure over time. This process occurs in response to environmental disturbances, such as fires, floods, or human interventions. By studying successional patterns, scientists gain insights into how communities recover and adapt to changing conditions.Succession is driven by interactions between species, environmental conditions, and resource availability. Understanding ecological succession is crucial for ecosystem management, restoration, and predicting the long-term trajectory of ecosystems following disturbances. Synecology is the study of ecological communities and the intricate relationships between species within them. It investigates species diversity, ecological succession, trophic interactions, and the impacts of human activities. By understanding these aspects, synecologists contribute to our knowledge of how ecosystems function and how to promote their conservation and sustainable management.

3.11. Terminal questions

Q. 1. What do know about synecology? Write the characteristics of synecology.

Answer:---

Q. 2. What is the ecotone? Discuss the role of ecotone species in ecosystem with examples.

Answer:---

Q. 3. What is the ecotype? Discuss the role of ecotypes species in ecosystem.

Answer:---

Q. 4. Discuss the speciation with examples in ecosystem.

Answer:---

Q. 5. What are ecological indicators? Discuss the role of ecological indicator for ecological balance.

Answer:---

Q. 6. What are ecological successions? Discuss the different types of ecological suction and its characteristics.

Answer:---

3.12. Further suggested readings

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Block-2 **UGEVS-102**

Rajarshi Tandon Open

Universitv. Pravaarai

Ecology and Biodiversity Conservation

Block- 2

Ecosystem

UNIT -4

Components of Ecosystem

UNIT-5

Trophic Levels

UNIT-6

Energy-its Flow in Ecosystem

UGEVS-102

Rajarshi Tandon Open University, Prayagraj

Ecology and Biodiversity Conservation

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Unit -4: Components of Ecosystem

Components

4.1. Introduction

Objectives

4.2. Ecosystem and its Types

4.3. Components of ecosystem

4.3.1. Biotic components

4.3.1. Abiotic components

4.4. Structure and function of ecosystem

4.5. Properties of ecosystem

4.6. Major ecosystems

4.6.1. Terrestrial ecosystem

4.5.2. Aquatic ecosystem

4.6.2. Biome ecosystem

4.7. Summary

4.8. Terminal questions

4.9. Suggested readings

4.1. Introduction:

The living (biotic) organism and their non-living (abiotic) environment are in reparably inter-related and interact upon each other. Any units in which there is interaction between organism and their physiochemical environment and between organism and materials between two is called ecosystem. It is the functional unit of ecology and is the highest level of ecological integration based on energy. The term ecosystem was coined by a British Ecologist A. G. Tansley in 1935. It is a dynamic system where biotic and abiotic components are constantly acting and reacting upon each other bringing forth structural and functional changes.

An organism is always in the state of perfect balance with the environment. The environment literally means the surroundings. The environment refers to the things and conditions around the organisms which directly or indirectly influence the life and development of the organisms and their populations. Organisms and environment are two non-separable factors. Organisms interact with each other and also with the physical conditions that are present in their habitats. "The organisms and the physical features of the habitat form an ecological complex or more briefly an ecosystem." (Clarke, 1954). Ecosystem structure is a network of interactions between abiotic and biotic components of the system and ecosystem functioning reflects the collective life activities of plants, animals, and microbes and the effects these activities (e.g., feeding, growing, moving, excreting waste) have on the physical and chemical conditions of their environment. The relationship between the abiotic components and the biotic components of the ecosystem is termed 'holocoenosis'.

Objectives:

- Define the details about ecosystem and its components.
- Understand the relationship or connection between living world and their surroundings.
- Understand the transfer of flow of energy in ecosystem

4.2. Ecosystem and its Types

The ecosystem is a chain of interactions between organisms and their environment. Ecosystem can be as small as an oasis in a desert, or as big as an ocean, spanning thousands of miles. There are two types of ecosystem:

- Terrestrial Ecosystem
- Aquatic Ecosystem

Terrestrial Ecosystem

Terrestrial ecosystems are exclusively land-based ecosystems. There are different types of terrestrial ecosystems distributed around various geological zones. The major terrestrial ecosystems occurring on a major region or sub continental level are called biomes although. Terms like provines, biochores, regions and formations are used by some ecologist. A given biomass is recognized by the types of vegetation cause and effect in biome distribution is confounded because of the complexity of interaction among the components, vegetation, climate and soil. Soil and vegetation are parts of same ecosystems. They development in parallel influencing each other and being influenced by climate. Soil climate vegetation interactions obviate distribution of biomes controlled by climate. Biome distribution and climate pattern are recorded in the growth of tree of rings and in fossilized pollen. The terrestrial ecosystems are as follows:

- Forest Ecosystem
- Grassland Ecosystem
- Tundra Ecosystem
- Desert Ecosystem

Aquatic Ecosystem

Aquatic ecosystems are ecosystems present in a body of water. It comprising more than 70 % of the earth surface, aquatic ecosystem are not only the dominant feature of earth but are also very diverse in species and complexity of interaction among their physical, chemical and biological components. These ecosystems are characterized as having running water (lotic) or still water (lentic). These can be further divided into two types, namely:

- Freshwater Ecosystem
- Marine Ecosystem

4.3. Components of ecosystem

Ecosystem is the major ecological unit. It has both structure and functions. The structure is related to species diversity. The more complex is the structure the greater is the diversity of the species in the ecosystem. According to Woodbury (1954), ecosystem is a complex in which habitat, plants and animals are considered as one interesting unit, the materials and energy of one passing in and out of the others.

Organisms and environment are two non-separable factors. Organisms interact with each other and also with the physical conditions that are present in their habitats.

"The organisms and the physical features of the habitat form an ecological complex or more briefly an ecosystem." (Clarke, 1954).

According to E.P. Odum, the ecosystem is the basic functional unit of organisms and their environment interacting with each other and with their own components. An ecosystem may be conceived and studied in the habitats of various sizes, e.g., one square meter of grassland, a pool, a large lake, a large tract of forest, balanced aquarium, a certain area of river and ocean. All the ecosystems of the earth are connected to one another, e.g., river ecosystem is connected with the ecosystem of ocean, and a small ecosystem of dead logs is a part of large ecosystem of a forest. A complete self-sufficient ecosystem is rarely found in nature but situations approaching self-sufficiency may occur.

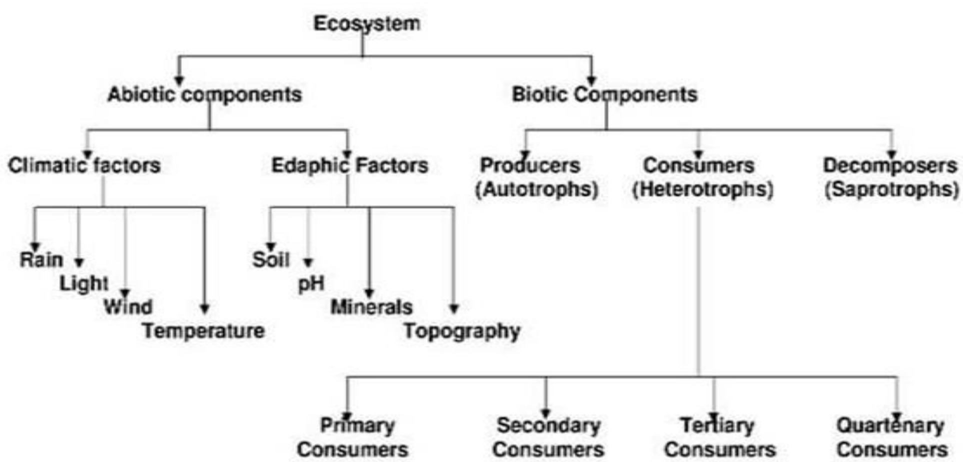

Fig.4.1. Components of ecosystem

Ecosystem is divided in two components such as

4.3.1. Abiotic Components of ecosystem

The abiotic components are usually materials and energy. Odum (1971) distinguished abiotic part into three components viz. i) inorganic like carbon, nitrogen, hydrogen etc. which are involved in cycling, 2) organic components like proteins, carbohydrate etc, which make the body of organism and, 3) the climate like temperature, light duration and intensity. The abiotic components of an ecosystem include the water, the air, the temperature and the rocks and minerals that make up the soil. The biotic components of the ecosystem both live on and interact with the abiotic components.

Abiotic factors are classified as

Climatic factors include the climatic regime of an area with physical factors in the environment such as light, atmospheric temperature, wind, humidity, etc (fig.2.1).

Edaphic factors, which relate to the composition and structure of the soil like its chemical and physical properties – like the soil type, soil profile, organic matter, minerals, soil water, and soil organisms. Inorganic substances like water, carbon, sulfur, nitrogen, phosphorus and so on. Organic substances like proteins, lipids, carbohydrates, humid substances etc.

The atmosphere provides carbon dioxide for photosynthesis and oxygen for respiration. The processes of evaporation, transpiration and precipitation cycle of water occurs between the atmosphere and the Earth's surface.

Solar radiation is used to heat the atmosphere and to evaporate and transpire water into the atmosphere. Sunlight is also necessary for photosynthesis. Photosynthesis provides the energy for plant growth and metabolism, and the organic food for other forms of life. Most living tissue is composed of a very high percentage of water, up to and even exceeding 90%. The protoplasm of a very few cells can survive if their water content drops below 10%, and most are killed if it is less than 30-50%.

Water is the medium by which mineral nutrients enter and are trans-located in plants. It is also necessary for the maintenance of leaf turgidity and is required for photosynthetic chemical reactions. Plants and animals receive their water from the Earth's surface and soil. The original source of this water is precipitation from the atmosphere.

Soils provide nutrients, water a home, and structural growing medium for organisms. The vegetation found growing on top soil is closely linked to this component of an ecosystem through nutrient cycle

4.3.2. Biotic Components of ecosystem:

The biotic components include all living organisms present in the environmental system. From nutritional point of view, the biotic components can be grouped into three basic components:

Autotrophic components

Autotrophs (from Greek: auto – self, trophos – feeder) are called **producers, transducers or converters,** as well. These are photosynthetic plants; which normally bear chlorophyll, which synthesizes a high-energy complex organic compound (or food) from the inorganic raw materials utilizing the sunlight, by the process of photosynthesis. Autotrophs form the core of all biotic systems. In terrestrial ecosystems, autotrophs are usually rooted plants. In the aquatic ecosystems, the floating plants referred to as phytoplankton and the shallow water rooted plants macrophytes are the main producers.

Heterotrophic components- Heterotrophs (from Greek: heteros – other; trophs – feeder) are the **consumers**. The consumers are also referred to as phagotrophs (phago – to swallow or ingest) while macro consumers are normally herbivores and carnivores.

Saprotrophs- Saprotrophs (from Greek again: sapros – rotten; trophies – feeder) are called the **reducers or decomposers**. They break the complex organic compounds in a dead matter (dead plants and animals). Decomposers don't ingest the food. Instead, they secrete a digestive enzyme into the dead, decaying plant or animal remains and digest this organic material. The enzymes act on the complex organic compounds in the dead matter. Decomposers absorb a bit of the decomposition products to provide themselves with nourishment. The remaining substance is added as minerals. The released minerals are utilized or reused as nutrients by plants – the producers.

So biotic components of an ecosystem can be described under the following three heads:

1. Producers (Autotrophic components),
2. Consumers, and
3. Decomposers or reducers and transformers

The amount of biomass at any time in an ecosystem is known as standing crop which is usually expressed as fresh weight, dry weight or as free energy in terms of calories/meter.

Producers (Autotrophic elements):

The producers are the autotrophic elements—chiefly green plants. They use radiant energy of sun in photosynthetic process, whereby carbon dioxide is assimilated and the light energy is converted into chemical energy. The chemical energy is actually locked up in the energy rich carbon compounds. Oxygen is evolved as by-product in the photosynthesis.

This is used in respiration by all living things. Algae and other hydrophytes of a pond, grasses of the field, and trees of the forests are examples of producers. Chemosynthetic bacteria and carotenoid bearing purple bacteria that also assimilate CO_2 with the energy of sunlight but only in the presence of organic compounds that also belong to this category.

The term producer is misleading one because in an energy context, producers produce carbohydrate and not energy. Since they convert or transduce the radiant energy into chemical form, E.J. Kormondy suggests better alternative terms ‘converters’ or ‘transducers’, because of wide use, the term producer is still **retained**.

Consumers:

Those living members of ecosystem which consume the food synthesized by producers are called consumers. Under this category are included all kinds of animals that are found in an ecosystem. There are different classes or categories of consumers, such as:

a) Consumers of the first order or primary consumers,
b) Consumers of the second order or secondary consumer
c) Consumers of the third order or tertiary consumers, and
d) Quaternary consumers.

(a) Primary consumers:

These are purely herbivorous animals that are dependent for their food on producers or green plants. Insects, rodents, rabbit, deer, cow, buffalo, goat are some of the common herbivores in the terrestrial ecosystem, and small crustaceans, molluscs, etc. in the aquatic habitat. Elton (1939) named herbivores of ecosystem as “key industry animals”. The herbivores serve as the chief food source for carnivores.

(b) Secondary consumers:

These are carnivores and omnivores. Carnivores are flesh eating animals and the omnivores are the animals that are adapted to consume herbivores as well as plants as their food. Examples of secondary consumers are sparrow, crow, fox, wolves, dogs, cats, snakes, etc.

(c) Tertiary consumers:

These are the top carnivores which prey upon other carnivores, omnivores and herbivores. Lions, tigers, hawk, vulture, etc. are considered as tertiary or top consumers.

(d) Quaternary consumers:

Quaternaryconsumers are often top predators within the environment, and they eat the tertiary consumers. Examples of quaternary consumers include lions, wolves, polar bears, humans, and hawks.

3. Decomposers and transformers:

Decomposers and transformers are the living components of the ecosystem and they are fungi and bacteria. Decomposers attack the dead remains of producers and consumers and degrade the complex organic substances into simpler compounds. The simple organic matters are then attacked by another kind of bacteria, the transformers which change these organic compounds into the inorganic forms that are suitable for reuse by producers or green plants. The decomposers and transformers play very important role in maintaining the dynamic nature of ecosystems.

4.4. Structure and function of ecosystem

The structure of an ecosystem refers to the physical and biological components that make up the system. Ecosystems can vary greatly in their structure, depending on factors such as climate, geography, and the organisms that inhabit them. In general, an ecosystem can be divided into two broad categories of components: abiotic and biotic. Abiotic components include non-living things like sunlight, water, air, and soil, while biotic components refer to living organisms such as plants, animals, fungi, and bacteria. The function of an ecosystem refers to the processes that take place within it, such as energy flow, nutrient cycling, and biological interactions. These functions are essential for maintaining the health and sustainability of the ecosystem.

The primary function of an ecosystem is to transfer energy from one organism to another through a food chain or food web. Producers, such as plants and algae, capture energy from the sun through photosynthesis and convert it into organic matter. This energy is then transferred to herbivores, which are consumed by carnivores and omnivores.

Another important function of ecosystems is nutrient cycling. As organisms die and decompose, nutrients are released into the soil, which are then taken up by plants and recycled back into the ecosystem. This process is critical for maintaining the health and productivity of ecosystems.

Biological interactions are also an essential function of ecosystems. Organisms interact with each other in various ways, such as through predation, competition, and mutualism. Predation is the ecological process by which energy is transferred from living animal to living organism based on behavior of a predator occupies the upper levels of food chain. Effective predation requires structural, functional and behavioral adaptations that value depends on the general organization. Bodily and size of the predator, the kind of predatory strategy adopted the general environmental conditions where predation is predicted and the defensive strategies of the available preys. Competition is a relationship between organism s that strives for the same resources in the same place. Intraspecific completion occurs between the members of the same species. It improves the specific adoptions, interspecific a competition occurs between member of the different species. The outcomes of this competition affect the specific growth, reproduction and survival.

Mutualism is most commonly defined in a way that reflect the positive signs characterizing the outcome of their interactions that is as interactions between individual of different species that benefits both of them. Mutualism can also be a symbiosis but all symbiosis are mutual and not all mutualism are symbiosis. Mutualism ranges from obligate to facultative hence they can be obligate-obligate, obligate-facultative or facultative-facultative. Facultative mutualisms are one whose population persist in the absence of a mutualism where as the obligate mutualism are ones whose populations go extinct in absence of a mutualism. These interactions can have a significant impact on the structure and dynamics of ecosystems.

Overall, the structure and function of ecosystems are intricately linked and work together to maintain the balance and sustainability of the system.

4.5. Properties of ecosystem

Ecosystem structure is a network of interactions between abiotic and biotic components of the system and ecosystem functioning reflects the collective life activities of plants, animals, and microbes that effects these activities (e.g., feeding, growing, moving, excreting waste) have on the physical and chemical conditions of their environment. The relationship between the abiotic components and the biotic components of the ecosystem is termed 'holocoenosis'. Each components in ecosystem play specific role in ecosystem such as plant in ecosystem produce organic chemical (food material) by process of photosynthesis while consumer perform their role in different tropic level to transfer energy form one trophic level to another. Abiotic factor also have important role in photosynthesis and mentioning ecological balance. Thus, ecosystem functioning reflects the collective life activities of plants, animals, and microbes and the effects these activities (feeding, growing, moving, excreting waste, etc.) on the physical and chemical conditions of their environment. The functions of ecosystem are to flow the energy and cycling of materials through structural components of the ecosystem. Ecosystems have several key properties that distinguish them from other systems. Here are some of the important properties of ecosystems.

- **Interconnectedness:** Ecosystems are composed of many different components, including living organisms, physical elements (such as soil, water, and air), and processes. These components are interconnected and interdependent, meaning that changes to one component can have cascading effects throughout the entire system.
- **Dynamics:** Ecosystems are constantly changing over the time due to a variety of factors, such as natural disturbances (such as fires and floods) and human activities (such as land use changes and pollution). Ecosystems have the ability to adapt and respond to these changes, but some changes can cause irreversible damage to the system.
- **Resilience:** Ecosystems have the ability to bounce back from disturbances and recover over the time. This property is called resilience, and it depends on factors such as the diversity and redundancy of species within the ecosystem.
- **Feedback loops**: Ecosystems are characterized by feedback loops, where the output of one process or component becomes the input for another. For example, the decomposition of organic matter by decomposers releases nutrients back into the soil, which can be taken up by plants to support their growth.
- **Self-organization**: Ecosystems are self-organizing systems, meaning that they exhibit emergent properties that cannot be predicted from the properties of individual components. This property is due to the complex interactions and feedback loops that occur within the system.
- **Heterogeneity:** Ecosystems are characterized by heterogeneity, meaning that they are composed of many different types of habitats and microhabitats that support a wide variety of species. This diversity of habitats and species is important for maintaining the overall health and functioning of the ecosystem.

4.6. Major ecosystems:

There are many different types of ecosystems on Earth, each with its unique set of physical and biological characteristics. Here are some of the major ecosystems:

4.6.1. Terrestrial ecosystems:

Terrestrial ecosystems are those that occur on land and are characterized by their dominant plant life. These ecosystems can range from small areas, such as a backyard garden, to vast expanses of land, such as forests and grasslands. Each terrestrial ecosystem has its unique set of physical and biological characteristics, and plays an important role in maintaining the health and functioning of the planet. Here are some of the major types of terrestrial ecosystems:

- **Forest ecosystems:** Forests are the most extensive terrestrial ecosystems on the planet, covering approximately 30% of the Earth's surface. They are characterized by a dominance of trees and other woody plants, and include tropical rainforests, temperate forests, and boreal forests.
- **Grassland ecosystems:** Grasslands are ecosystems characterized by a dominance of grasses and other herbaceous plants. They occur in areas with moderate to low precipitation and include savannas, prairies, and steppes.
- **Desert ecosystems**: Deserts are ecosystems characterized by low precipitation and high temperatures. They include hot deserts, cold deserts, and semi-arid ecosystems.
- **Tundra ecosystems:** Tundra is a type of ecosystem characterized by low temperatures and a short growing season. It includes Arctic tundra and alpine tundra.
- **Chaparral ecosystems**: Chaparral is a type of ecosystem characterized by a dominance of shrubs, and occurs in regions with Mediterranean climates. It is found in areas such as southern California, the Mediterranean region, and parts of Australia.
- **Alpine ecosystems:** Alpine ecosystems occur at high elevations and are characterized by cold temperatures, strong winds, and a short growing season. They include alpine tundra and subalpine forests.
- **Taiga ecosystems:** Taiga is a type of forest ecosystem found in cold regions, characterized by a dominance of coniferous trees. It occurs in regions such as Canada, Alaska, and Russia.

4.6.2. Aquatic ecosystems

These are ecosystems that occur in water, and include marine ecosystems (such as coral reefs, estuaries, and Open Ocean) and freshwater ecosystems (such as rivers, lakes, and wetlands). Aquatic ecosystems are those that occur in water and can be divided into two broad categories: freshwater ecosystems and marine ecosystems. Each aquatic ecosystem has its unique set of physical and biological characteristics, and plays an important role in maintaining the health and functioning of the planet. Aquatic ecosystems are particularly important for providing ecosystem services, such as regulating the climate, providing food and freshwater, and supporting biodiversity. Here are some of the major types of aquatic ecosystems:

- **Rivers and streams:** Rivers and streams are freshwater ecosystems that are characterized by flowing water. They are important habitats for a wide variety of fish, amphibians, and aquatic invertebrates, (lentic ecosystem)
- **Lakes and ponds:** Lakes and ponds are freshwater ecosystems that are characterized by standing water. They are important habitats for a wide variety of aquatic plants, fish, and other organisms, (lotic ecosystem).
- Wetlands: Wetlands are ecosystems that occur where water meets land. They are characterized by standing water and a wide variety of vegetation, and are important habitats for a wide variety of aquatic and terrestrial organisms.
- **Coral reefs:** Coral reefs are marine ecosystems that are characterized by a diversity of coral species and other marine organisms. They are important habitats for a wide variety of fish and other marine organisms.
- **Estuaries:** Estuaries are ecosystems where rivers meet the ocean. They are characterized by brackish water and a variety of vegetation, and are important habitats for a wide variety of fish and other marine organisms.
- **Open Ocean:** The open ocean is a marine ecosystem that covers the vast majority of the Earth's surface. It is characterized by deep water and a wide variety of marine organisms, including fish, whales, and sharks.

4.6.3. Biomes ecosystem

Biomes, as unit of study there are interactions between different communities of area. Biomes are very large ecological areas on the earth′s surface, with fauna and flora (animals and plants) adapting to their environment. Biome is different from an ecosystem. An ecosystem is the interaction of living and nonliving things in an environment. A biome is a specific geographic area notable for the species living there. A biome is a large-scale ecosystem that is defined by the dominant vegetation and climatic conditions of a region. Biomes are characterized by their unique set of plant and animal species, as well as their specific climate patterns. The major biomes of the world are:

- **Tropical rainforest biome**: The tropical rainforest biome is characterized by a high level of rainfall and warm temperatures year-round. This biome is found in Central and South America, Africa, and Southeast Asia, and is home to a wide variety of plant and animal species.
- **Desert biome:** The desert biome is characterized by low levels of rainfall and high temperatures during the day, with cooler temperatures at night. This biome is found in regions such as the Sahara in Africa, the Mojave in North America, and the Gobi in Asia.
- **Grassland biome:** The grassland biome is characterized by a dominance of grasses and other herbaceous plants. This biome is found in regions such as the Great Plains of North America, the savannas of Africa, and the pampas of South America.
- **Temperate deciduous forest biome:** The temperate deciduous forest biome is characterized by moderate temperatures and a range of precipitation, with four distinct seasons. This biome is found in regions such as North America, Europe, and Asia, and is home to a wide variety of plant and animal species.
- **Taiga biome:** The taiga biome, also known as the boreal forest, is characterized by cold temperatures and coniferous trees. This biome is found in regions such as Canada, Alaska, and Russia, and is home to a wide variety of plant and animal species.
- **Tundra biome:** The tundra biome is characterized by very cold temperatures and a short growing season. This biome is found in regions such as northern Canada, Alaska, and Russia, and is home to a wide variety of plant and animal species.

Each biome has its unique set of physical and biological characteristics, and plays an important role in maintaining the health and functioning of the planet. Biomes are important for providing ecosystem services, such as regulating the climate, providing food and freshwater, and supporting biodiversity.

These are just a few examples of major different types of ecosystems on Earth. Each ecosystem has its unique set of physical and biological characteristics, and plays an important role in maintaining the health and functioning of the planet. Apart form that some small types of ecosystem also exists such as

- **Wetland ecosystems:** These are ecosystems characterized by standing water, and include swamps, marshes, and bogs.

- **Coastal ecosystems:** These are ecosystems that occur in the interface between land and sea, and include salt marshes, mangrove forests, and coral reefs.
- **Urban ecosystems:** These are ecosystems that occur in urban areas, and include parks, gardens, and other green spaces that provide habitat for a variety of plant and animal species.

These are just a few examples of the many different types of ecosystems found in nature. Each ecosystem has its unique set of physical and biological characteristics, and plays an important role in maintaining the health and functioning of the planet.

4.7. Summary

All the ecosystems of the earth are connected to one another, e.g., river ecosystem is connected with the ecosystem of ocean, and a small ecosystem of dead logs is a part of large ecosystem of a forest. An ecosystem is a structural and functional unit of ecology where the living organisms interact with each other and the surrounding environment. In other words, an ecosystem is a chain of interactions between organisms and their environment. The term "Ecosystem" was first coined by A.G.Tansley, an English botanist, in 1935. Ecosystem structure is a network of interactions between abiotic and biotic components of the system and ecosystem functioning reflects the collective life activities of plants, animals, and microbes and the effects these activities (e.g., feeding, growing, moving, excreting waste) have on the physical and chemical conditions of their environment

4.8. Terminal questions

Q.1: What is ecosystem, Define the natural and artificial ecosystem?

Answer: --

Q.2: What is the structure and function of the ecosystem?

Answer: --

Q.3: Write the properties natural and artificial ecosystem.

Answer: --

Q.4: Discuss briefly aquatic ecosystem and its role in ecological balance.

Answer: --

Q.5: What is the biome, discuss it briefly.

Answer: --

4.9. Further suggested readings

17. S.C. Sandra, "Environmental Science", A New Central Book Agency, 2008.

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UNIT-5: Tropic Level

Components

5.1. Introduction

Objectives

5.2. Energy Flow in Ecosystem

5.3. Food chain

5.4. Types of Food Chains

5.4.1. Significance of food chain

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5.7.1. Types of ecological pyramid

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5.1. Introduction

Trophic level, steps in a nutritive series or food chain of an ecosystem. The organisms of a chain are classified into these levels on the basis of their feeding behaviour. A food web starts at trophic level with primary producers such as plants, can move to herbivores at level 2, carnivores' level 3 or higher, and typically finish with apex predators at level 4 or 5. The patch along the chain can from either a one-way flow or a food web. The ecological community with higher biodiversity form more complex trophic paths. A trophic level is the group of organisms within an ecosystem which occupy the same level in a food chain. There are five main trophic levels within a food chain, each of which differs in its nutritional relationship with the primary energy source. The primary energy source in any ecosystem is the Sun (although there are exceptions in deep sea ecosystems).

The solar radiation from the Sun provides the input of energy which is used by primary producers, also known as autotrophs. Primary producers are usually plants and algae, which perform photosynthesis in order to manufacture their own food source. Primary producers make up the first trophic level.

The rest of the trophic levels are made up of consumers, also known as heterotrophs; heterotrophs cannot produce their own food, so must consume other organisms in order to acquire nutrition.

The second trophic level consists of herbivores, these organisms gain energy by eating primary producers and are called primary consumers.

Trophic levels three, four and five consist of carnivores and omnivores. Carnivores are animals that survive only by eating other animals, whereas omnivores eat animals and plant material.

Trophic level three consists of carnivores and omnivores which eat herbivores; these are the secondary consumers.

Trophic level four contains carnivores and omnivores which eat secondary consumers and are known as tertiary consumers.

Trophic level five consists of apex predators; these animals have no natural predators and are therefore at the top of the food chain.

Decomposers or detritivores are organisms which consume dead plant and animal material, converting it into energy and nutrients that plants can use for effective growth..

It is important to note that organisms within the trophic levels of natural ecosystems do not generally form a uniform chain, and that many animals can have multiple prey and multiple predators. The non-linear interactions of trophic levels can therefore be best viewed as a food web rather than a food chain. However, disruption within one of the trophic levels, for example, the extinction of a predator, or the introduction of a new species, can have a drastic effect on either the lower or higher trophic levels.

5.2. Energy Flow in Ecosystem

The flow of energy in ecosystems is vitally important to the thriving of life on Earth. Nearly all of the energy in Earth's ecosystems originates within the Sun. Once this solar energy reaches Earth, it is distributed among ecosystems in an extremely complex manner. A simple way to analyze this distribution is through a food chain or food web.

Energy flow is the flow of energy through living things within an ecosystem. All living organisms can be organized into producers and consumers, and those producers and consumers can further be organized into a food chain. Each of the levels within the food chain is a trophic level.

How Organisms Acquire Energy in a Food Web

All living things require energy in one form or another since energy is required by most, complex, metabolic pathways (often in the form of ATP); life itself is an energy-driven process. Living organisms would not be able to assemble macromolecules (proteins, lipids, nucleic acids, and complex carbohydrates) from their monomeric subunits without a constant energy input.

It is important to understand how organisms acquire energy and how that energy is passed from one organism to another through food webs and their constituent food chains. Food webs illustrate how energy flows directionally through ecosystems, including how efficiently organisms acquire it, use it, and how much remains for use by other organisms of the food web. Energy is acquired by living things in three ways: photosynthesis, chemosynthesis, and the consumption and digestion of other living or previously-living organisms by heterotrophs.

Photosynthetic and chemosynthetic organisms are grouped into a category known as autotrophs: organisms capable of synthesizing their own food (more specifically, capable of using inorganic carbon as a carbon source). Photosynthetic autotrophs (photoautotrophs) use sunlight as an energy source, whereas chemosynthetic autotrophs (chemoautotrophs) use inorganic molecules as an energy source. Autotrophs act as producers and are critical for all ecosystems. Without these organisms, energy would not be available to other living organisms and life itself would not be possible.

Photoautotrophs, such as plants, algae, and photosynthetic bacteria, serve as the energy source for a majority of the world's ecosystems. These ecosystems are often described by grazing food webs. Photoautotrophs harness the solar energy of the sun by converting it to chemical energy in the form of ATP (and NADP). The energy stored in ATP is used to synthesize complex organic molecules, such as glucose.

Chemoautotrophs are primarily bacteria that are found in rare ecosystems where sunlight is not available, such as in those associated with dark caves or hydrothermal vents at the bottom of the ocean. Many chemoautotrophs in hydrothermal vents use hydrogen sulfide (H_2S), which is released from the vents, as a source of chemical energy. This allows chemoautotrophs to synthesize complex organic molecules, such as glucose, for their own energy and in turn supplies energy to the rest of the ecosystem.

Heterotrophs function as consumers in the food chain; they obtain energy in the form of organic carbon by eating autotrophs or other heterotrophs. They break down complex organic compounds produced by autotrophs into simpler compounds, releasing energy by oxidizing carbon and hydrogen atoms into carbon dioxide and water, respectively. Unlike autotrophs, heterotrophs are unable to synthesize their own food. If they cannot eat other organisms, they will die.

5.3. Food Chain

In ecosystem, every organism depends on other organisms for food material and all organisms are (herbivores to carnivores) arranged in a series in which food energy is transferred through a repeated series of eating and being eaten. It is called **foodchain**.

- In the food chain, energy flow is in the form of food.

- In a food chain, food material or food energy transfer from one trophic level to the next trophic level.
- Four trophic levels are present in the ecosystem because level of energy decreases during the flow of energy from one trophic to another trophic level.

1) First trophic level [T1] = Producers
2) Second trophic level [T2] = Primary consumers
3) Third trophic level [T3] = Secondary consumers
4) Fourth trophic level [T4] = Top consumers

There are five trophic levels found in highly complex ecosystem in which tertiary consumer is present in between the secondary consumers and top consumers. Then the fifth trophic level (T5) is formed by the top consumer.

5) Shorter food chains will provide greater energy.
6) Generally the decomposers (bacteria and fungi) are not included in the food chain but when included then there are at as the last tropic level.

5.4. Types of Food Chains

In nature, **three** types of food chains are present: Grazing food chain, parasitic food chain and detritus food chain.

1. Grazing Food Chains or Predatory Food Chain:

Most of the food chain in nature is of this type. This food chain begins with producers (plants) and in successive order it goes from small organism to large organism.

Aquatic ecosystem

Producer	Primary consumer	Secondary consumer	Top consumer
↑	↑	↑	↑
Phytoplankton →	Zooplankton →	Largefish →	Smallfish
↓	↓	↓	↓
T_1	T_2	T_3	T_4

Grassland ecosystem

Producer	Primary consumer	Secondary consumer	Top consumer
↑	↑	↑	↑
Grass →	Rabbit →	Fox	→ Lion
↓	↓	↓	↓
T_1	T_2	T_3	T_4

2. Parasitic Food Chain

This food chain also starts from producers but in successive order it goes, from big organism to the smaller organism.

Tree ecosystem

Tree	→	Birds →	Parasites
↓		↓	↓
T_1		T_2	T_3

Both grazing and parasitic food chains are directly dependent on solar radiation (as a primary source of energy) and have rapid energy flow.

3. Detritus Food Chain or Saprophytic Food Chain

- This food chain begins with decomposition of dead organic matter by decomposers, so it is also known as saprophytic food chain.
- In this food chain, primary consumers are bacteria and fungi.
- In mangrove vegetation, this food chain goes up to big organism.

Dead mangroves leaves → Bacteria & fungi → Amphipods, molluscs, crabs, nematodes → Small fishes → Fish eating birds.

- In detritus food chain, energy flow is rather very slow yet magnitude of energy is great because vast number of decomposers is involved.
- Detritus food chain does not depend on light.

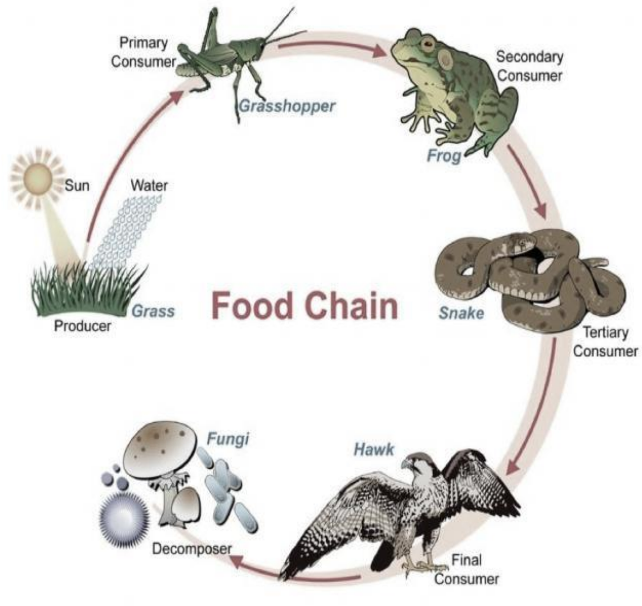

Fig.5.1: Food Chain

5.4.1. Significance of food chain:

1. The studies of food chain help to understand the feeding relationship and the interaction between organisms in any ecosystem.
2. They also help us to appreciate the energy flow mechanism and matter circulation in ecosystem and understand the movement of toxic substances in the ecosystem.
3. The study of food chain helps us to understand the problems of bio-magnifications.

5.5. Food Web

- Food web is an important ecological concept. Basically, food web represents feeding relationships within a community (Smith and Smith 2009). It also implies the transfer of food energy from its source in plants through herbivores to carnivores (Krebs 2009).
- In a food web, transfer of food energy is unidirectional but from many different alternative pathways.
- In a food web, members of a particular trophic level obtain their food according to their choice and taste. It means they have more than one option or alternative for getting food.

- As much as food web in complex ecosystem is more permanent or stable, such type of ecosystem is not destroyed naturally and continues for a long time. This ecosystem is not affected by loss of any organism of any particular trophic level. Those ecosystems which have simple food web are not very stable. It means that they can be finished at any time, if there is a change in any particular trophic level.
- A food web (or food cycle) is the natural interconnection of food chains and a graphical representation (usually an image) of what-eats-what in an ecological community. Another name for food web is **consumer-resource system.** Ecologists can broadly lump all life forms into one of two categories called trophic levels: 1) Autotrophs, and 2) Heterotrophs.
- Many interconnected food chains make up a food web. When you look at the larger picture, a food web shows a realistic representation of the energy flow through different organisms in an ecosystem.

Sometimes, a single organism gets eaten by many predators or it eats many other organisms. This is when a food chain doesn't represent the energy flow in a proper manner because there are many trophic levels that interconnect. This is where a food web comes into place. It shows the interactions between different organisms in an ecosystem. The following diagram shows the energy flow between various organisms through a food web.

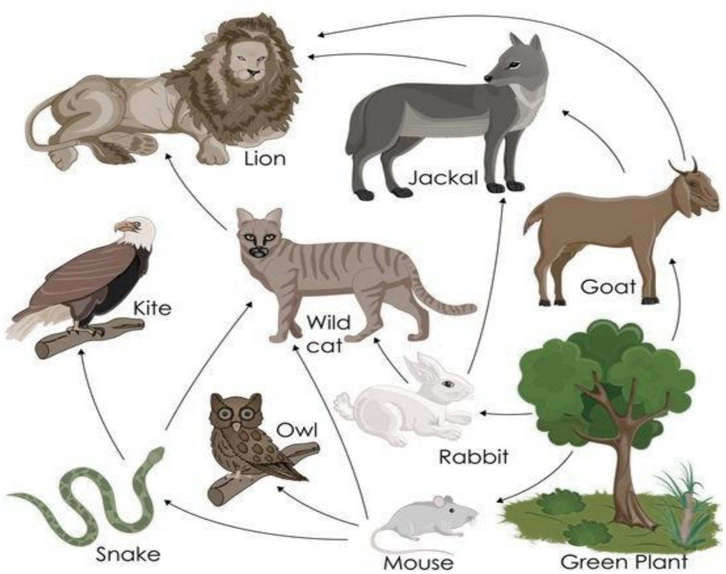

Fig.5.2: Food Web

5.6. Productivity within Trophic Levels

Productivity, measured by gross and net primary productivity, is defined as the amount of energy that is incorporated into a biomass.

Productivity within an ecosystem can be defined as the percentage of energy entering the ecosystem incorporated into biomass in a particular trophic level. Biomass is the total mass in a unit area (at the time of measurement) of living or previously-living organisms within a trophic level. Ecosystems have characteristic amounts of biomass at each trophic level.

The productivity of the primary producers is especially important in any ecosystem because these organisms bring energy to other living organisms by photoautotrophy or chemoautotrophy. **Photoautotrophy** is the process by which an organism (such as a green plant) synthesizes its own food from inorganic material using light as a source of energy; **chemoautotrophy**, on the other hand, is the process by which simple organisms (such as bacteria or archaea) derive energy from chemical processes rather than photosynthesis. **The rate at which photosynthetic primary producers incorporate energy from the sun is called gross primary productivity (G.P.P.)**.

Because all organisms need to use some of this energy for their own functions (such as respiration and resulting metabolic heat loss), scientists often refer to the **net primary productivity (N.P.P.)** of an ecosystem. Net primary productivity is the energy that remains in the primary producers after accounting for the organisms' respiration and heat loss. The net productivity is then available to the primary consumers at the next trophic level.

Transfer of Energy between Trophic Levels

Energy is lost as it is transferred between trophic levels; the efficiency of this energy transfer is measured by **TLTE** and **NPE.**

Ecological efficiency: the transfer of energy between trophic levels

Large amounts of energy are lost from the ecosystem between one trophic level and the next level as energy flows, from the primary producers through the various trophic levels of consumers and decomposers. The main reason for this loss is the second law of thermodynamics, which states that whenever energy is converted from one form to another, there is a tendency toward disorder (entropy) in the system. In biologic systems, this means a great deal of energy is lost as metabolic heat when the organisms from one trophic level are consumed by the next level. The measurement of energy transfer efficiency between two successive trophic levels is termed the **trophic level transfer efficiency** (TLTE) and is defined by the formula:

$$\text{TLTE} = \frac{\text{Energy transferred to next level}}{\text{Energy received during transfer}} \times 100$$

The 10% Law of Energy Flow

In general, only about 10% of energy is transferred from one trophic level to the next, and this number can vary from 5-20% depending on the ecosystem. This means that 90% of obtained energy is lost at each trophic level, greatly affecting the maximum number of possible levels in the ecosystem. For example, if an ecosystem received 600,000 Kcal of solar energy from the sun, primary producers would pass on only 60,000 Kcal to herbivores, which would pass only 6,000 Kcal to secondary consumers, 600 Kcal to tertiary consumers and 60 Kcal to quaternary consumers at the top of the food chain. An apex predator like a wolf—needing an average of 2000 Kcal per day—would need to consume a very high quantity of secondary or tertiary consumers to meet its calorie quota per day (**Fig**.2.7).

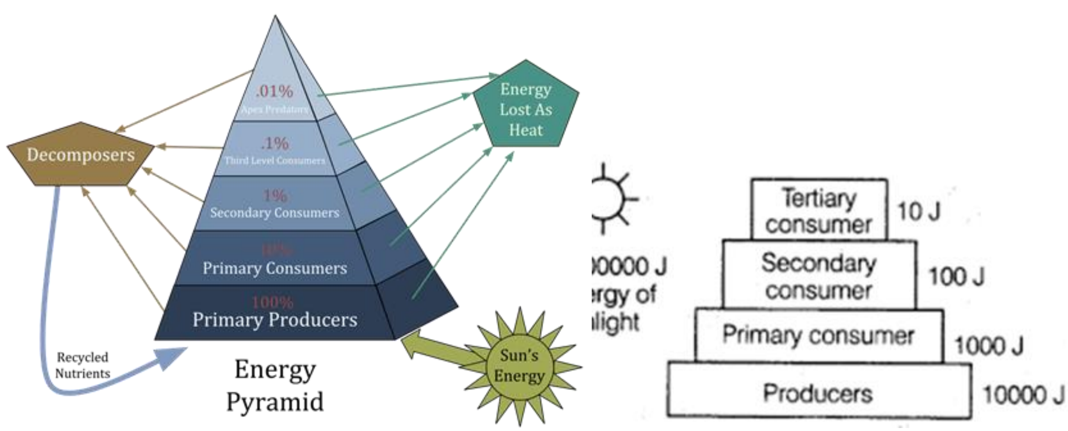

Fig.5.3 : Ecological Pyramid

Net production efficiency

Another main parameter that is important in characterizing energy flow within an ecosystem is the net production efficiency. Net production efficiency (NPE) allows ecologists to quantify how efficiently organisms of a particular trophic level incorporate the energy they receive into biomass. It is calculated using the following formula:

$$\text{N.P.E.} = \frac{\text{Net primary productivity}}{\text{G.P.P.}} \times 100$$

Net consumer productivity is the energy content available to the organisms of the next trophic level. Assimilation is the biomass (energy content generated per unit area) of the present trophic level after accounting for the energy lost due to incomplete ingestion of food, energy used for respiration, and energy lost as waste. Incomplete ingestion refers to the fact that some consumers eat only a part of their food. For example, when a lion kills an antelope, it will eat everything except the hide and bones. The lion is missing the energy-rich bone marrow inside the bone, so the lion does not make use of all the calories its prey could provide.

Thus, NPE measures how efficiently each trophic level uses and incorporates the energy from its food into biomass to fuel the next trophic level. In general, cold-blooded animals (ectotherms), such as invertebrates, fish, amphibians, and reptiles, use less of the energy they obtain for respiration and heat than warm-blooded animals (endotherms), such as birds and mammals. The extra heat generated in endotherms, although an advantage in terms of the activity of these organisms in colder environments is a major disadvantage in terms of NPE. Therefore, many endotherms have to eat more often than ectotherms to obtain the energy they need for survival. In general, NPE for ectotherms is an order of magnitude (10x) higher than for endotherms. For example, the NPE for a caterpillar eating leaves has been measured at 18 percent, whereas the NPE for a squirrel eating acorns may be as low as 1.6 percent.

The inefficiency of energy use by warm-blooded animals has broad implications for the world's food supply. It is widely accepted that the meat industry uses large amounts of crops to feed livestock. Because the NPE is low, much of the energy from animal feed is lost. For example, it costs about $0.01 to produce 1000 dietary calories (kcal) of corn or soybeans, but approximately $0.19 to produce a similar number of calories growing cattle for beef consumption. The same energy content of milk from cattle is also costly, at approximately $0.16 per 1000 kcal. Much of this difference is due to the low NPE of cattle. Thus, there has been a growing movement worldwide to promote the consumption of non-meat and non-dairy foods so that less energy is wasted feeding animals for the meat industry.

5.7. Ecological Pyramid

An ecological pyramid is a graphical representation of the relationship between different organisms in an ecosystem. Each of the bars that make up the pyramid represents a different trophic level, and their order, which is based on who eats whom, represents the flow of energy.

It can be observed that these pyramids are in the shape of actual pyramids with the base being the broadest, which is covered by the lowest trophic level, i.e., producers. The next level is occupied by the next trophic level, i.e., the primary consumers and so on.

All the calculations for construction of these types of ecological pyramids must take into account all the organisms in a particular trophic level because a sample space of a few numbers or a few species will end up giving a huge level of errors.

5.7.1. Types of Ecological Pyramid

Three types of ecological pyramid exist. They are as follows:

1. Pyramid of Numbers
2. Pyramid of Energy
3. Pyramid of Biomass

1. Pyramid of Numbers:

In this type of ecological pyramid, the number of organisms in each trophic level is considered as a level in the pyramid. The pyramid of numbers is usually **upright** except for some situations like that of the detritus food chain, where many organisms feed on one dead plant or animal (**Fig.**5.4).

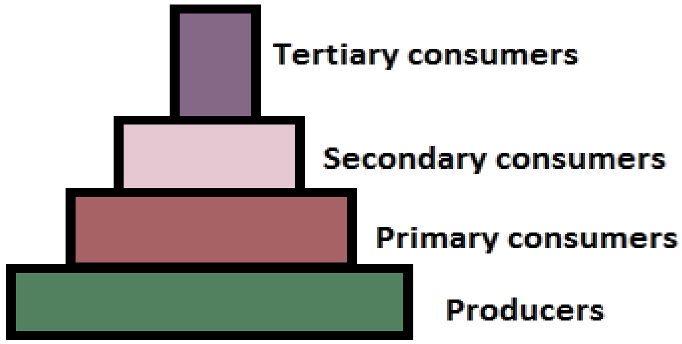

Fig. 5.4: Pyramid of Numbers

2. Pyramid of Biomass:

In this particular type of ecological pyramid, each level takes into account the amount of biomass produced by each trophic level. The pyramid of biomass is also **upright** except for that observed in oceans where large numbers of zooplanktons depend on a relatively smaller number of phytoplanktons (**Fig.**5.5).

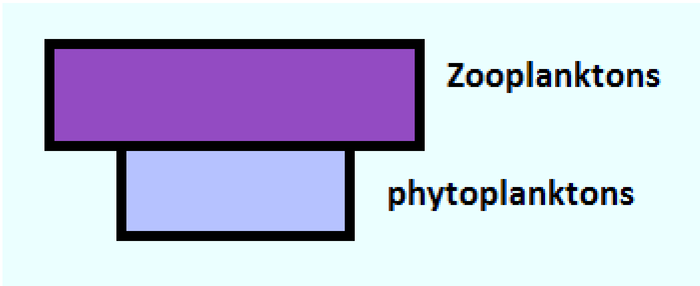

Fig.5.5: Pyramid of Biomass (in ocean)

3. Pyramid of Energy:

Pyramid of energy is the only type of ecological pyramid, which is **alwaysupright** as the energy flow in a food chain is always unidirectional. Also, with every increasing trophic level, some energy is lost into the environment (**Fig.** 5.6)..

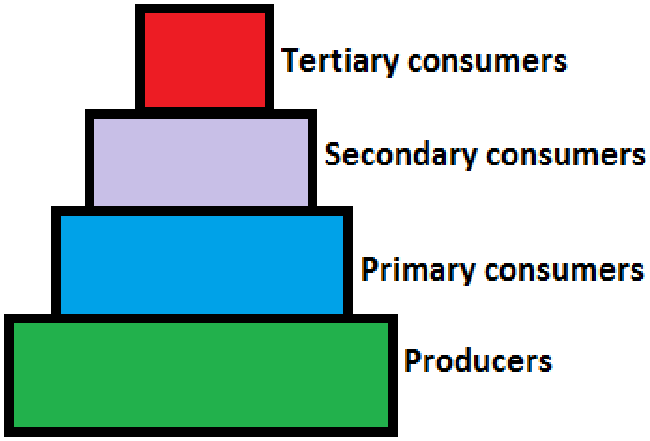

Fig.5.6: Pyramid of energy

Importance of Ecological Pyramid

The importance of ecological pyramid can be explained in the following points:

- They show the feeding of different organisms in different ecosystems.
- It shows the efficiency of energy transfer.
- The condition of the ecosystem can be monitored, and any further damage can be prevented.

Limitations of the Ecological Pyramid

1. More than one species may occupy multiple trophic levels as in case of the food web. Thus, this system does not take into account food webs.
2. The saprophytes are not considered in any of the pyramids even though they form an important part of the various ecosystems.
3. These pyramids are applicable only to simple food chains, which usually do not occur naturally.
4. These pyramids do not deliver any concept in relation to variations in season and climate.
5. They do not consider the possibility of the existence of the same species at different levels.

5.8.Summary

Trophic levels play a fundamental role in understanding the structure and dynamics of ecological systems. It describes the feeding relationships and energy transfer within an ecosystem. Organisms in an ecosystem can be classified into different trophic levels based on their source of nutrition and their role in energy flow. In ecology, a trophic level refers to the position of an organism in a food chain or food web. It represents the flow of energy and nutrients within an ecosystem, highlighting the feeding relationships between different organisms. Ecosystems consist of a complex web of interactions between organisms, with energy flowing from one trophic level to another. The trophic levels are generally categorized as producers, primary consumers, secondary consumers. In addition to these primary trophic levels, there can be further divisions or categories based on the complexity of the food web. For example, omnivores are organisms that can consume both plants and animals, occupying multiple trophic levels depending on their diet. Understanding trophic levels is crucial for studying the structure and dynamics of ecosystems, including the flow of energy and the impacts of disruptions or changes within food webs. It's important to note that energy is transferred between trophic levels, but not all energy is efficiently transferred. The energy flow between trophic levels is often represented by an ecological pyramid, where each higher trophic level contains less energy compared to the lower trophic levels. This is because energy is lost as heat or used for metabolic processes as it moves through the food chain.

5.9.Terminal questions

Q.1. What is the trophic level in ecosystem? Discuss the basic features of trophic level in brief.

Answer: ---

Q.2. What is the producers, discuss the role of producers in trophic level.

Answer: ---

Q.3. Discuss the energy flow model in ecosystem.

Answer: ---

Q.4. What is the food chain and food web? Write the types of food chains.

Answer: ---

Q.5. Discuss the Productivity within Trophic Levels.

Answer: ---

Q.6. What are the ecological pyramids? Write the types of ecological pyramid.

Answer: ---

5.10. Suggested readings

1. S.C. Sandra, "Environmental Science", A New Central Book Agency, 2008.
2. P.D. Sharma, "Ecology and Environment" Rastogi Publications, 2017
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Unit-6: Energy-its Flow in Ecosystem

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6.1. Introduction

Energy is the capacity to work and all living things must work. In the sun light temperature acts as a nuclear furnace where nuclear rearrangement like continuous transmutation of hydrogen atoms into helium is taking place. This process releases fantastically high amounts of energy which radiates out in all directions in the form of electromagnetic radiations called solar radiation. A very minutes part of this radiation i.e. about one fifty millionth of the suns energy output reaches the earth atmosphere. The green plant has evolved a mechanism of trapping and converting it into the chemical form of energy. Solar energy travelling in the form of radiation called radiant energy. Part of this radiant energy is wavelength between 40 nm to 70 is the visible range of light energy. Light energy is readily converted into heat energy as can be seen in the open sun when light waves striking the ground is converted partly into heat which warms the soil or other objects. The light energy entering the chloroplast machinery of the plant body is taken up by electrons of the chlorophyll molecule and passed on through series of stage into chemical energy in the bonds of organic compounds. Different forms of energy interchange their forms under certain set of rules. These are defined in two lows of thermodynamics. 1) Energy cannot be created or destroyed but may be converted form one form to another. 2)

Process involving energy transformations will not occurs spontaneously unless there is a degradation of energy form non-random to a random form.

Energy flow is a fundamental process that drives the functioning and structure of ecosystems. It begins with the capture of solar energy by autotrophs through photosynthesis, which is then transferred to higher trophic levels through feeding interactions. The energy flow is not efficient, with significant energy losses occurring at each transfer. Decomposers play a vital role in recycling energy back into the ecosystem. Understanding energy flow is crucial for comprehending the dynamics and interconnectedness of ecosystems, as well as for addressing conservation and management challenges in the face of environmental changes. The concept of energy flow also extends beyond the boundaries of a single ecosystem. It recognizes that ecosystems are interconnected and form larger-scale systems. Energy can flow between ecosystems through migration of organisms or through processes such as nutrient runoff and atmospheric transport. These connections highlight the importance of considering energy flow on a broader scale, known as landscape or global energy flow.

Objectives

- To discuss the energy sources in ecosystem
- To discuss the three way of energy flow model of ecosystem
- To discuss the Y shaped energy flow model of ecosystem

6.2. Energy in ecosystem

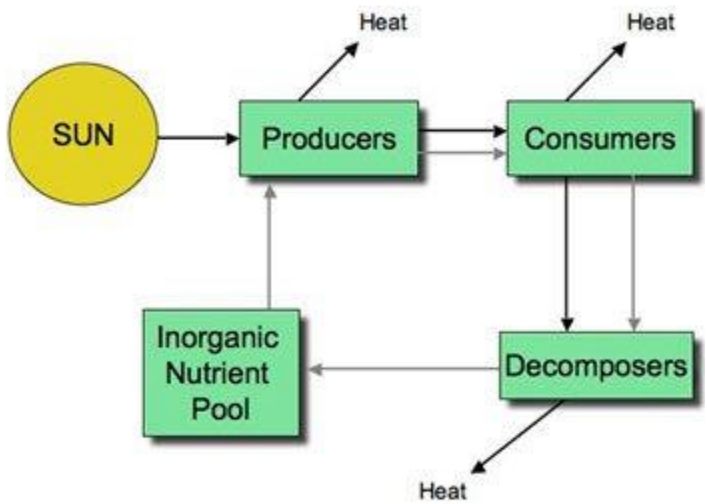
Energy flow is a fundamental concept in ecology that describes the transfer and transformation of energy within an ecosystem. It is a crucial process that sustains life and influences the structure and functioning of ecological communities. The vast majority of energy that exists in food webs originates from the sun and is converted (transformed) into chemical energy by the process of photosynthesis in plants. A small proportion of this chemical energy is transformed directly into heat when compounds are broken down during respiration in plants Understanding energy flow is essential for comprehending the intricate interconnections and dynamics that exist within an ecosystem. At the heart of the energy flow in ecosystems it is the sun, which serves the ultimate source of energy. Sunlight, in the form of solar radiation, is captured by green plants and other photosynthetic organisms through a process called photosynthesis. These organisms, known as producers or autotrophs, convert solar energy into chemical energy in the form of carbohydrates, such as glucose. This process establishes the foundation of the food chain or food web. The energy stored in the organic compounds produced by the autotrophs is then passed on to other organisms within the ecosystem. Herbivores, also known as primary consumers, feed on the producers, acquiring the energy stored in the plant tissues. The energy transfer continues as secondary consumers, such as carnivores, feed on the herbivores. This process can extend further up to the food chain, with tertiary consumers preying on secondary consumers. With each transfer of energy from one trophic level to the next, a significant portion of the energy is lost as heat. This loss occurs during metabolic processes, such as respiration and movement, and is governed by the second law of thermodynamics. Consequently, energy flow through an ecosystem is not efficient, and only a fraction of the energy is transferred from one trophic level to the next. This limits the number of trophic levels that can be sustained in a given ecosystem. The energy flow within an ecosystem can also take different pathways. Some of the energy captured by autotrophs is used for growth, reproduction, and maintenance of their own metabolic processes. This energy is referred to as primary production and is denoted as gross primary production (GPP). However, not all of the GPP is available to support higher trophic levels. Some of the energy is used by the autotrophs themselves in cellular respiration, resulting in a net primary production (NPP). NPP represents the energy available for consumption by herbivores and, subsequently, by higher trophic levels. Energy flow within an ecosystem is not restricted to the transfer between trophic levels but also involves nonliving components, such as decomposers. Decomposers, including bacteria and fungi. They break down organic matter from dead organisms and waste materials, releasing energy in the process. This energy is cycled back into the ecosystem, making it available for reuse by autotrophs.

6.3. Energy sources in ecosystem

Energy is derived from various sources in ecosystem that contribute to the overall energy flow and sustenance of life. These energy sources can be categorized into two main types: abiotic and biotic.

a. Abiotic Energy Sources:

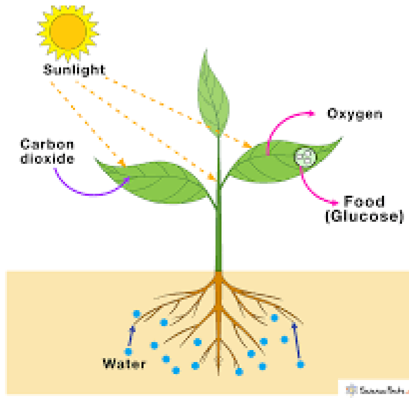
- **Solar Energy:** The sun is the primary source of energy for ecosystems. Sunlight provides the energy required for photosynthesis, the process by which autotrophic organisms convert solar energy into chemical energy. It is the basis of the food chain and the primary driver of ecosystem productivity.



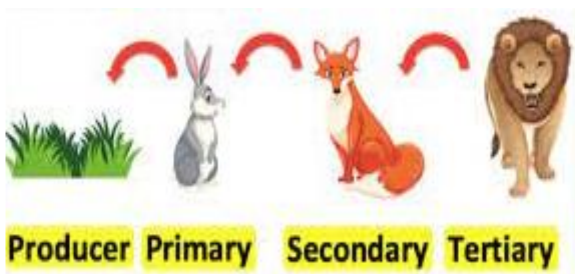
- **Geothermal Energy**: Geothermal energy refers to the heat energy generated from within the Earth's core. In some ecosystems, particularly near geothermal vents or hot springs, organisms can utilize this geothermal energy to carry out metabolic processes. Certain bacteria and archaea, known as thermophiles, thrive in extreme conditions and derive energy from geothermal sources.
- **Chemical Energy:** Chemical energy in ecosystems can be obtained from various sources. For example, in chemosynthetic ecosystems, such as deep-sea hydrothermal vents, energy is derived from chemical reactions rather than sunlight. Chemosynthetic bacteria utilize the energy from chemical compounds, such as hydrogen sulfide, to produce organic matter.
- **Wind Energy:** Wind energy indirectly contributes to the energy flow in ecosystems. Wind aids in the dispersal of seeds and pollen, promoting plant reproduction and the establishment of new individuals. It also influences microclimates, which can affect the distribution and behavior of organisms.

b. Biotic Energy Sources:

- **Autotrophs:** Autotrophic organisms, primarily plants and algae, are the primary producers in ecosystems. They have the ability to convert abiotic energy sources, such as sunlight, into chemical energy through photosynthesis. Autotrophs play a crucial role in energy capture and serve as the foundation of the food chain.



- **Heterotrophs:** The organisms that generally prepare their own food, through the process of Photosynthesis, are defined as Autotrophs. Heterotrophic organisms obtain energy by consuming other organisms. All types of plants, trees, and shrubs, are categorized into autotrophs. The process of Photosynthesis is made possible in plants, because of a special pigment cell called Chlorophyll, which is actively used in producing food in the leaves, and also generating energy by absorbing sunlight. Moreover, using the Photosynthesis process, the autotrophs absorb carbon dioxide from the atmosphere and release oxygen as a by-product.



They can be classified into various trophic levels based on their feeding habits.

Primary consumers, or herbivores, directly feed on autotrophs, acquiring energy from the organic matter produced by plants.

Secondary consumers, such as carnivores, prey on herbivores, obtaining energy from the herbivores' tissues.

Tertiary consumers occupy higher trophic levels and feed on other carnivores.

Decomposers, including bacteria and fungi, break down organic matter from dead organisms, releasing energy and nutrients back into the ecosystem.

- **Detritivores:** Detritivores are organisms that feed on detritus, which consists of dead plant and animal material. They play a crucial role in the decomposition process, breaking down organic matter and releasing energy in the form of nutrients. Examples of detritivores include earthworms, woodlice, and some species of insects.

- **Mutualistic Relationships:** Mutualistic interactions between different species can also contribute to energy flow in ecosystems. For example, certain plants have mutualistic relationships with nitrogen-fixing bacteria, where the bacteria provide the plant with fixed nitrogen while receiving energy-rich carbohydrates in return. Similarly, pollination by insects or other animals helps in plant reproduction and contributes to the overall energy flow within the ecosystem.

It is important to note that energy flow within ecosystems is not a linear process but rather a complex network of interactions. Energy is constantly being transferred, transformed, and recycled within and between trophic levels. Additionally, the efficiency of energy transfer decreases with each trophic level due to energy losses in the form of heat and metabolic processes. As a result, higher trophic levels generally have fewer individuals and biomass compared to lower trophic levels.

6.4. Energy flow model in ecosystem

The energy flow model in an ecosystem illustrates the transfer and transformation of energy through different trophic levels. It represents the flow of energy from the primary producers to consumers and decomposers, highlighting the interconnections and dependencies within the ecosystem. The energy flow model is based on the following key components:

- **Autotrophs (Producers):** Autotrophic organisms, primarily plants and algae, are the primary producers in ecosystems. They capture solar energy through photosynthesis and convert it into chemical energy in the form of organic compounds, primarily carbohydrates. This process establishes the foundation of the energy flow in the ecosystem.
- **Heterotrophs (Consumers):** Heterotrophic organisms obtain energy by consuming other organisms. They can be classified into different trophic levels based on their feeding habits. Primary consumers, or herbivores, directly feed on autotrophs, acquiring the energy stored in plant tissues. Secondary consumers, such as carnivores, prey on herbivores, obtaining energy from the herbivores' tissues. Tertiary consumers occupy higher trophic levels and feed on other carnivores. The energy flow between trophic levels is often depicted in a pyramid-like structure, with energy decreasing as it moves up the food chain.

- **Decomposers:** Decomposers, including bacteria and fungi, play a vital role in the energy flow model. They break down organic matter from dead organisms, as well as waste materials, and convert them into simpler inorganic compounds. Through decomposition, energy is released back into the ecosystem, making it available for reuse by autotrophs and completing the energy cycle.
- **Energy Losses**: At each trophic level, energy is lost in the form of heat and metabolic processes. This loss occurs during respiration, movement, and other biological activities. According to the second law of thermodynamics, energy transformations are not 100% efficient, resulting in a decrease in available energy as it moves through the food chain. As a result, each trophic level contains a smaller amount of energy compared to the preceding level.

The energy flow model in an ecosystem can be represented through ecological pyramids. These pyramids illustrate the energy transfer and biomass distribution across different trophic levels. In a pyramid of energy, each level represents the amount of energy available, with the primary producers forming the base and higher trophic levels successively occupying smaller sections. This pyramid reflects the decrease in available energy as it moves up the food chain. Additionally, ecological pyramids can also represent the biomass or the number of individuals at each trophic level. A pyramid of biomass shows the total amount of living organic matter at each level, while a pyramid of numbers represents the number of individuals in each trophic level. The energy flow model in an ecosystem is a representation of the transfer and transformation of energy from primary producers to consumers and decomposers. It highlights the interconnectedness and dependencies within the ecosystem and demonstrates the decreasing amount of available energy as it moves up the trophic levels. Understanding this model is crucial for studying ecological dynamics, trophic interactions, and the overall functioning of ecosystems.

Characteristics of Autotrophs and Heterotrophs

From the above section, we can understand that both the Autotrophs and Heterotrophs are equally important for the food chains and the ecosystems. Thus, they have many unique characteristics such as,

- Autotrophs and Heterotrophs play an active role in maintaining the energy flow in the ecosystem.

- Autotrophs can only prepare the food themselves, because of the special pigments in leaves called Chlorophyll.
- And Heterotrophs consume food directly or indirectly by relying on Autotrophs.
- In the food chain, Autotrophs are the primary-level organisms, followed by Heterotrophs, placed in secondary and tertiary organisms.
- Moreover, the type of nutrition employed by these organisms helps them differentiate into Autotrophs and Heterotrophs.

6.5. Basic energy flow model

The basic energy flow model illustrates the movement of energy through a simple system, such as an ecosystem or a food chain. It outlines the flow of energy from its source to different components within the system

Energy Source: The energy flow model starts with an external source of energy, often the sun in natural ecosystems. The sun provides radiant energy in the form of sunlight.

Producers: The energy from the sun is captured by autotrophic organisms, such as plants or algae, through the process of photosynthesis. For example the Grasses in a grassland ecosystem convert sunlight, carbon dioxide (CO_2), and water (H_2O) into glucose ($C_6H_{12}O_6$) and oxygen (O_2) through photosynthesis. Thus it converts solar energy into chemical energy in the form of carbohydrates. The general chemical equation for photosynthesis is:

$$6CO_2 + 6H_2O + \text{sunlight} \rightarrow C_6H_{12}O_6 + 6O_2$$

Primary Consumers: Herbivores or primary consumers obtain energy by consuming producers. They derive their energy from the carbohydrates and other organic compounds produced by plants. It consumes plant material, such as leaves, fruits, or seeds, to obtain energy. They extract the chemical energy stored in the organic compounds produced by primary producers. For example: A rabbit feeding on grass obtains energy from the stored glucose in the plant material.

Secondary Consumers: Secondary consumers are carnivores or omnivores that feed on primary consumers.They obtain energy by consuming the flesh of other organisms. For example: A snake preying on the rabbit consumes the stored energy in the rabbit's body, utilizing the organic compounds and converting them into its own energy.

Tertiary Consumers: Tertiary consumers are predators that feed on secondary consumers. They acquire energy from consuming other carnivores or omnivores. A hawk preying on the snake acquires energy from the snake's body by consuming is the example of tertiary consumer.

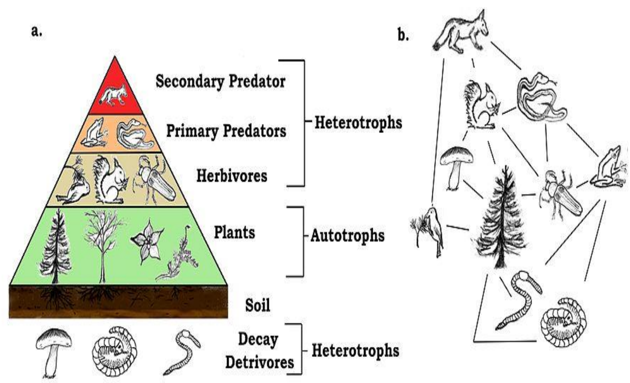


Fig.5.1: Producer and consumers

Decomposers: Decomposers break down organic matter, including dead organisms, feces, and plant litter. They release energy through the process of decomposition, returning nutrients to the ecosystem. Like Bacteria and fungi decompose the remains of dead plants and animals, breaking down complex organic compounds into simpler molecules and releasing energy in the process.

Energy Loss: At each trophic level, there is a loss of energy due to metabolic processes, heat dissipation, and waste production. This energy loss occurs during digestion, respiration, and other metabolic activities.

Energy Flow and Cycling: Energy flows through the system, with energy being transferred from one trophic level to another. Some of the energy is stored and used for growth and reproduction, while the rest is lost as heat. The energy that is not utilized by organisms eventually returns to the environment and becomes available for new energy cycles.

It is important to note that the basic energy flow model is a simplified representation of energy transfer within a system where transfer of energy from one trophic level to another within an ecosystem, with energy being passed along the food chain. It also highlights the importance of decomposers in recycling nutrients and energy back into the ecosystem. In reality, ecosystems and food chains are more complex, with multiple interconnected pathways and feedback loops.

Nonetheless, the basic energy flow model provides a useful starting point for understanding the fundamental principles of energy transfer and the interconnectedness of organisms within a system.

How Organisms Acquire Energy in a Food Web

All living things require energy in one form or another since energy is required by most, complex, metabolic pathways (often in the form of ATP); life itself is an energy-driven process. Living organisms would not be able to assemble macromolecules (proteins, lipids, nucleic acids, and complex carbohydrates) from their monomeric subunits without a constant energy input. It is important to understand how organisms acquire energy and how that energy is passed from one organism to another through food webs and their constituent food chains. Food webs illustrate how energy flows directionally through ecosystems, including how efficiently organisms acquire it, use it, and how much remains for use by other organisms of the food web. Energy is acquired by living things in three ways: photosynthesis, chemosynthesis, and the consumption and digestion of other living or previously-living organisms by heterotrophs.

Photosynthetic and chemosynthetic organisms are grouped into a category known as autotrophs: organisms capable of synthesizing their own food (more specifically, capable of using inorganic carbon as a carbon source). Photosynthetic autotrophs (photoautotrophs) use sunlight as an energy source, whereas chemosynthetic autotrophs (chemoautotrophs) use inorganic molecules as an energy source. Autotrophs act as producers and are critical for all ecosystems. Without these organisms, energy would not be available to other living organisms and life itself would not be possible. Photoautotrophs, such as plants, algae, and photosynthetic bacteria, serve as the energy source for a majority of the world's ecosystems. These ecosystems are often described by grazing food webs. Photoautotrophs harness the solar energy of the sun by converting it to chemical energy in the form of ATP (and NADP). The energy stored in ATP is used to synthesize complex organic molecules, such as glucose.

Chemoautotrophs are primarily bacteria that are found in rare ecosystems where sunlight is not available, such as in those associated with dark caves or hydrothermal vents at the bottom of the ocean. Many chemoautotrophs in hydrothermal vents use hydrogen sulfide (H_2S), which is released from the vents, as a source of chemical energy. This allows chemoautotrophs to synthesize complex organic molecules, such as glucose, for their own energy and in turn supplies energy to the rest of the ecosystem.

Heterotrophs function as consumers in the food chain; they obtain energy in the form of organic carbon by eating autotrophs or other heterotrophs. They break down complex organic compounds produced by autotrophs into simpler compounds, releasing energy by oxidizing carbon and hydrogen atoms into carbon dioxide and water, respectively. Unlike autotrophs, heterotrophs are unable to synthesize their own food. If they cannot eat other organisms, they will die.

Productivity within Trophic Levels

Productivity, measured by gross and net primary productivity, is defined as the amount of energy that is incorporated into a biomass.

Productivity within an ecosystem can be defined as the percentage of energy entering the ecosystem incorporated into biomass in a particular trophic level. Biomass is the total mass in a unit area (at the time of measurement) of living or previously-living organisms within a trophic level. Ecosystems have characteristic amounts of biomass at each trophic level.

The productivity of the primary producers is especially important in any ecosystem because these organisms bring energy to other living organisms by photoautotrophy or chemoautotrophy. **Photoautotrophy** is the process by which an organism (such as a green plant) synthesizes its own food from inorganic material using light as a source of energy; **chemoautotrophy**, on the other hand, is the process by which simple organisms (such as bacteria or archaea) derive energy from chemical processes rather than photosynthesis. **The rate at which photosynthetic primary producers incorporate energy from the sun is called gross primary productivity (G.P.P.)**.

Because all organisms need to use some of this energy for their own functions (such as respiration and resulting metabolic heat loss), scientists often refer to the **net primary productivity (N.P.P.)** of an ecosystem. Net primary productivity is the energy that remains in the primary producers after accounting for the organisms' respiration and heat loss. The net productivity is then available to the primary consumers at the next trophic level.

Transfer of Energy between Trophic Levels

Energy is lost as it is transferred between trophic levels; the efficiency of this energy transfer is measured by **TLTE** and **NPE.**

Ecological efficiency: the transfer of energy between trophic levels

Large amounts of energy are lost from the ecosystem between one trophic level and the next level as energy flows, from the primary producers through the various trophic levels of consumers and decomposers. The main reason for this loss is the second law of thermodynamics, which states that whenever energy is converted from one form to another, there is a tendency toward disorder (entropy) in the system. In biologic systems, this means a great deal of energy is lost as metabolic heat when the organisms from one trophic level are consumed by the next level. The measurement of energy transfer efficiency between two successive trophic levels is termed the **trophic level transfer efficiency** (TLTE) and is defined by the formula:

$$\text{TLTE} = \frac{\text{Energy transferred to next level}}{\text{Energy received during transfer}} \times 100$$

The 10% Law of Energy Flow

In general, only about 10% of energy is transferred from one trophic level to the next, and this number can vary from 5-20% depending on the ecosystem. This means that 90% of obtained energy is lost at each trophic level, greatly affecting the maximum number of possible levels in the ecosystem. For example, if an ecosystem received 600,000 Kcal of solar energy from the sun, primary producers would pass on only 60,000 Kcal to herbivores, which would pass only 6,000 Kcal to secondary consumers, 600 Kcal to tertiary consumers and 60 Kcal to quaternary consumers at the top of the food chain. An apex predator like a wolf—needing an average of 2000 Kcal per day—would need to consume a very high quantity of secondary or tertiary consumers to meet its calorie quota per day (**Fig**.2.7).

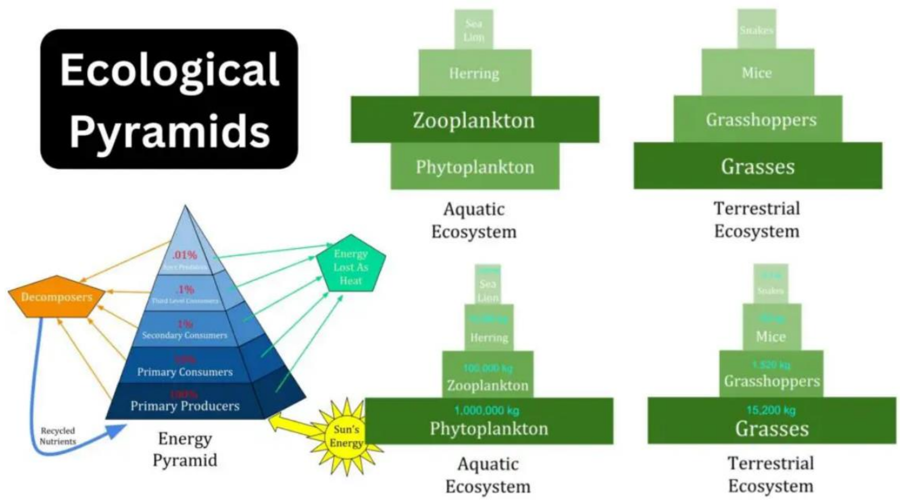


Fig. 2.7 : Ecological Pyramid

Net production efficiency

Another main parameter that is important in characterizing energy flow within an ecosystem is the net production efficiency. Net production efficiency (NPE) allows ecologists to quantify how efficiently organisms of a particular trophic level incorporate the energy they receive into biomass. It is calculated using the following formula:

$$\text{N.P.E.} = \frac{\text{Net primary productivity}}{\text{G.P.P.}} \times 100$$

Net consumer productivity is the energy content available to the organisms of the next trophic level. Assimilation is the biomass (energy content generated per unit area) of the present trophic level after accounting for the energy lost due to incomplete ingestion of food, energy used for respiration, and energy lost as waste. Incomplete ingestion refers to the fact that some consumers eat only a part of their food. For example, when a lion kills an antelope, it will eat everything except the hide and bones. The lion is missing the energy-rich bone marrow inside the bone, so the lion does not make use of all the calories its prey could provide.

Thus, NPE measures how efficiently each trophic level uses and incorporates the energy from its food into biomass to fuel the next trophic level. In general, cold-blooded animals (ectotherms), such as invertebrates, fish, amphibians, and reptiles, use less of the energy they obtain for respiration and heat than warm-blooded animals (endotherms), such as birds and mammals. The extra heat generated in endotherms, although an advantage in terms of the activity of these organisms in colder environments is a major disadvantage in terms of NPE. Therefore, many endotherms have to eat more often than ectotherms to obtain the energy they need for survival. In general, NPE for ectotherms is an order of magnitude (10x) higher than for endotherms. For example, the NPE for a caterpillar eating leaves has been measured at 18 percent, whereas the NPE for a squirrel eating acorns may be as low as 1.6 percent.

The inefficiency of energy use by warm-blooded animals has broad implications for the world's food supply. It is widely accepted that the meat industry uses large amounts of crops to feed livestock. Because the NPE is low, much of the energy from animal feed is lost. For example, it costs about $0.01 to produce 1000 dietary calories (kcal) of corn or soybeans, but approximately $0.19 to produce a similar number of calories growing cattle for beef consumption. The same energy content of milk from cattle is also costly, at approximately $0.16 per 1000 kcal. Much of this difference is due to the low NPE of cattle. Thus, there has been a growing movement worldwide to promote the consumption of non-meat and non-dairy foods so that less energy is wasted feeding animals for the meat industry.

6.6. Single flow energy model in ecosystem

In the context of an ecosystem, a single flow energy model refers to a simplified representation of energy flow within a specific trophic level or pathway. It focuses on tracking the energy transfer from primary producers (plants or algae) to primary consumers (herbivores) or from primary consumers to secondary consumers. The single or linear channel energy flow model is one of the first published models pioneered by H. T. Odum in 1956. As can be seen in Fig. 5.2, this model depicts a community boundary and, in addition to light and heat flows, it also includes import, export and storage of organic matter.

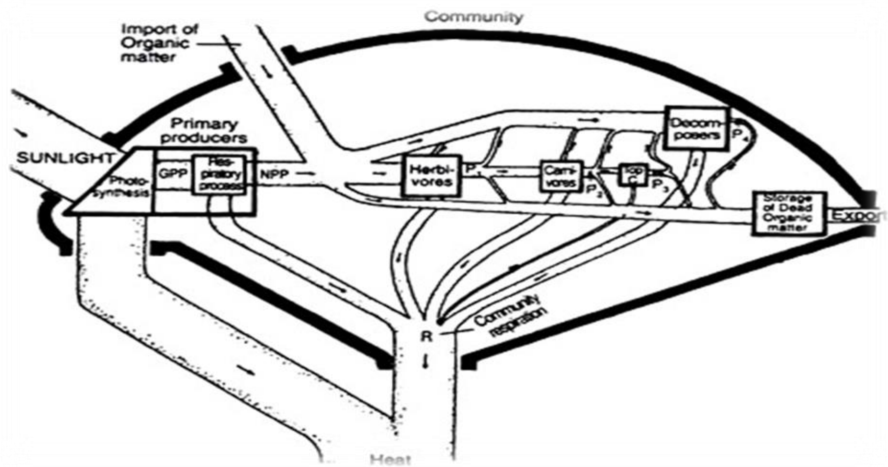


Fig.5.2: Single or linear channel energy flow diagram (P_1, P_2, P_3 and P_4 secondary production of the indicated level (H. T. Odum, 1956)

Decomposer organisms are placed in a separate box as a means of partially separating the grazing and detritus food chains. Decomposers are actually a mixed group in terms of energy levels and their importance in this energy flow model is overlooked. This model will suffice as long as only the imports and exports are considered.

Characteristics of single flow energy model

- The single flow energy model simplifies the complex energy dynamics within an ecosystem by focusing on a specific trophic level or pathway.
- It provides a basic understanding of energy transfer from one group of organisms to another within a simplified context.
- In this model, energy flows in a unidirectional manner from the primary producers (plants or algae) to the consumers (herbivores) within the trophic level being considered.
- It illustrates the transfer of energy from one set of organisms to another as they consume and utilize the energy stored in organic matter.
- The model incorporates the concept of trophic efficiency, which represents the efficiency with which energy is transferred from one trophic level to the next.
- Trophic efficiency accounts for energy losses due to metabolic processes, growth, and heat production.
- It is typically estimated to be around 10% in ecological systems, meaning that approximately 10% of energy is transferred from one trophic level to the next.

- The single flow energy model allows for the quantification of energy transfer within the trophic level being considered.
- It provides a numerical estimate of the amount of energy available to consumers based on the energy captured by primary producers and the trophic efficiency.
- The model has a limited scope as it focuses on a specific trophic level or pathway and does not account for the complexities of multiple trophic interactions, feedback loops, or energy flows between different trophic levels.
- The single flow energy model does not consider the role of decomposers, detritivores, and the breakdown of organic matter.
- It simplifies the energy flow by excluding the energy recycling processes associated with the decomposition of dead organisms and organic waste.

Limitation of single flow energy

- The single flow energy model provides a simplified representation of energy flow within a specific trophic level.
- It overlooks the intricate complexities of interactions between different trophic levels, feedback loops, and the interconnectedness of energy flows in a diverse ecosystem.
- The model does not account for the multiple trophic interactions that occur in ecosystems.
- The single flow energy model typically disregards spatial and temporal variations in energy flow.
- Energy dynamics can differ across different habitats within an ecosystem and can change over the time due to seasonal variations, migrations, or disturbances.
- The model assumes a constant trophic efficiency, usually estimated at around 10%, which represents the fraction of energy transferred from one trophic level to the next.
- The single flow energy model does not consider the role of decomposers, detritivores, and the breakdown of organic matter.
  - The single flow energy model is not suitable for complex ecosystems with multiple trophic levels, diverse species interactions, and intricate food webs.
  - It cannot fully capture the energy dynamics and trophic interactions that occur in such ecosystems.

6.7. Y Shaped energy flow in ecosystem

The Y-shaped energy flow in an ecosystem refers to a specific pattern of energy transfer and flow that occurs in certain ecosystems with multiple energy pathways. Unlike the traditional linear energy flow model, where energy flows in a single direction from primary producers to consumers and decomposers, the Y-shaped energy flow model shows the divergence and convergence of energy within the ecosystem. In the Y-shaped energy flow model, energy from primary producers (autotrophs) is divided into two or more energy pathways that support different consumer populations. Each pathway represents a different set of trophic interactions and energy transfers. These pathways can be determined by the availability of resources, environmental conditions, or specific ecological relationships. As energy flows through these different pathways, the trophic levels may vary, and different consumer populations may occupy separate branches of the Y-shaped model. This pattern allows for greater complexity and diversity within the ecosystem, as different organisms can utilize different energy sources and occupy distinct niches. At the convergence point of the Y-shaped energy flow model, energy from the separate branches merges and is channeled into decomposers. Decomposers play a crucial role in breaking down organic matter from dead organisms and recycling nutrients and energy back into the ecosystem. This process ensures that the energy is cycled and made available for reuse by primary producers, closing the energy loop. The Y-shaped energy flow model can be observed in various ecosystems. For example, in aquatic ecosystems, primary producers such as phytoplankton may support two distinct consumer pathways: one through herbivorous zooplankton and another through detritivores that feed on organic matter and decaying material. Both pathways eventually merge at the decomposition stage. The Y-shaped energy flow model highlights the complexity and interconnectedness of ecosystems, emphasizing the existence of multiple energy pathways and trophic interactions. It acknowledges that energy flow is not limited to a linear chain but can be distributed and utilized in various ways within an ecosystem. By incorporating this model into ecological studies, scientists can better understand the dynamics, energy flow patterns, and resilience of ecosystems.

6.8. Two channel energy flow model

The two-channel energy flow model refers to a specific pattern of energy transfer and flow within an ecosystem that involves two distinct energy pathways. In the two-channel energy flow model, primary producers, such as plants or algae, convert solar energy into chemical energy through photosynthesis. From this point, energy is divided into two primary pathways that support different trophic levels within the ecosystem.

Channel 1: Grazing/Food Chain Pathway

In the first channel, energy flows through a traditional grazing or food chain pathway. Herbivores or primary consumers consume the primary producers, acquiring energy from the organic matter stored in plant tissues. These herbivores serve as a link between primary producers and higher trophic levels. Energy is then transferred to secondary consumers, such as carnivores, which prey on the herbivores. The energy flow may continue through tertiary consumers or top predators that feed on the secondary consumers. At each trophic level, energy is partially transferred, and a portion is lost as heat or used for metabolic processes.

Channel 2: Detritus/Food Web Pathway

The second channel in the two-channel energy flow model involves detritus or the decomposition pathway. In this pathway, energy flows through decomposers, including bacteria, fungi, and detritivores. These organisms break down organic matter from dead organisms, such as leaf litter, fallen trees, or animal carcasses. By decomposing organic matter, they release energy and nutrients back into the ecosystem. This energy can be utilized by detritivores, which directly feed on the decomposing organic matter. Detritivores can be insects, earthworms, or other organisms that contribute to the breakdown process. The energy from detritivores can further support other trophic levels, including secondary consumers that feed on detritivores, creating a complex network of interactions known as a detritus or decomposer food web.

The two-channel energy flow model recognizes the significance of both grazing-based trophic interactions and the detritus-based decomposition processes in the ecosystem. It highlights the importance of considering multiple energy pathways and the interconnectedness of trophic relationships within the ecosystem. This model provides a more comprehensive understanding of energy flow dynamics and the functioning of ecological communities.

6.9. Summary

The primary source of energy in ecosystems is sunlight, captured by autotrophic organisms through photosynthesis. Autotrophs, such as plants and algae, convert solar energy into chemical energy in the form of organic compounds. This process establishes the foundation of the food chain or food web. Energy transfer occurs through trophic levels, which consist of different consumer populations. Herbivores, or primary consumers, feed directly on autotrophs, acquiring the energy stored in plant tissues. Secondary consumers, such as carnivores, prey on herbivores, obtaining energy from the herbivores' tissues. This energy flow can extend further up the food chain, with tertiary consumers preying on other carnivores. At each trophic level, energy is partially transferred, and a significant portion is lost as heat or used for metabolic processes. This limits the number of trophic levels that can be sustained in an ecosystem. Decomposers, including bacteria and fungi, play a crucial role in recycling energy within ecosystems. Energy flow in ecosystems is not linear but can take different pathways. Some ecosystems exhibit a Y-shaped energy flow, where energy diverges into multiple channels, supporting different consumer populations before converging at the decomposition stage. Understanding energy in ecosystems is essential for comprehending the dynamics and interconnections within ecological communities. It highlights the complexity of trophic interactions, the importance of primary producers as the basis of energy flow, and the role of decomposers in nutrient recycling. Energy flow also influences the distribution, abundance, and diversity of organisms within an ecosystem.

6.10. Terminal questions

Q.1. How solar energy is useful in ecosystem? Explain it.

Answer:--

Q.2. Disuses the role of producers in energy flow in ecosystem.

Answer:--

Q.3. What is the energy flow model?

Answer:--

Q.4. Discuss the Y shaped energy flow model in ecosystem.

Answer:--

Q.5. Discuss the three channel energy flow model in ecosystem.

Answer:--

Q.6. Discuss the role of decomposer in energy flow in ecosystem.

Answer:--

6.11. Further suggested readings

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Rajarshi Tandon Open University, Prayagraj

Ecology and Biodiversity Conservation

Block- 3

Biodiversity

UNIT -7

Introduction to Biodiversity

UNIT-8

Biodiversity Conservation

UNIT-9

Biodiversity Assessment

UGEVS-102

Rajarshi Tandon Open University, Prayagraj

Ecology and Biodiversity Conservation

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Unit 7- Introduction to Biodiversity

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7.1. Introduction

Life on earth originated nearly 4.0 billion years ago, and during this period several species have evolved and become extinct. The biological world is a massive heterogenous group, extending from simple unicellular organisms to complex multicellular forms. Hence, it can be said that Diversity is the rule of Nature. Biological diversity is the outcome of organic evolution, variation due to natural hybridisation, mutation and adaptation by living organisms to diverse environments.The term biodiversity was coined by W.G. Rosen in 1986.

The interdependence and co-existence of various life forms maintain the balance of nature. Biodiversity thus maintains the populations, food chains, and nutrient cycle in the ecosystem. Human beings aredepend on biodiversity for food, medicines, materials, or for ecological services. A minimum level of biodiversity is necessary for proper functioning of the ecosystem. Unfortunately, the biodiversity is being increasingly threatened by environmental degradation and we have entered a sixth phase of mass extinction of species per day from tropical forest alone. Extinction of one species from tropical forests often leads to extinction of several other species of the food chain.

India is a country rich in biodiversity, and is one of the twelve megadiversity countries in the world. The biological wealth of the country is relevant to the health of biosphere in general, and to agriculture, animal husbandry, fisheries, forestry and pharmaceutical industry in particular. There is, however, a growing threat to this natural wealth and it needs conservation to check its loss.

Biodiversity hot spots were originally identified in 1990s. Hot spot is an area which faces serious threat for human activities and supports a unique biodiversity with representatives of evolutionary processes of speciation and extinction. The rate of deforestation in these areas is very high and ecosystem have reached at a fragile stage. The highest concentration of species is found in these areas. The special hot spots are the mangroves, wetlands, and swamps.

Objectives

- ✓ To discuss the concept of biodiversity and its types
- ✓ To discuss significance of biodiversity
- ✓ To discuss loss of biodiversity
- ✓ To discuss Biodiversity Hotspots

7.2. Concept of Biodiversity

Biodiversity refers to the variance among different species of plants, animals and microorganisms; ecosystems; ecosystem including terrestrial, aerial, marine and other aquatic system and ecological complexes of which they are part. In simpler terms, biodiversity is the collection of different life forms.

Approximately, more than 50 million species of animals, plants and micro-organisms are living in this world, of which about 1.4 million species have been recognized until now. Each species is adjusted to survive in particular environment, from mountaintop to the sea depth, from polar ice caps to tropical rain forests and deserts.All this life forms are limited to about only one-kilometre-thick layers, within the biosphere. Though, environment and ecology has been studied for so long,Walter Rosen coined the term biodiversity in 1986. Biological diversity is known as variety and variability among the living beings and the ecological complexes in which they arise.

Biodiversity, besides its environmental importance provides a socio-economic and monetary benefit to the country. Human society relies upon biological resources, their diversity and the ecological community that support them to provide necessary goods and services.

Biodiversity in India – Flora, and Fauna

India is famous for its diverse and rich fauna and flora, which habitats over 500 mammal species, greater than 200 different varieties of bird species, and 3000 insect species. The Zoological Survey of India based at Kolkata is accountable for examining the animal kingdom in India. India also has varied climate, terrain, landscape, and habitation and are recognized to have affluent flora across the world covering 18000 flowering plant species. These flowering plant species comprises of 6-7% of the earths plant species.The eight major floristic regions of India include- the Western and the Eastern Himalayas, Indus and Ganges, Assam, the Deccan, Malabar, and the Andaman Islands, which itself is houses over 3000 Indian species of plant. The forests in India spans from the tropical rainforest embracing Andaman, Western Ghats, and northeast India to the Himalayan coniferous forests. The deciduous forests can be observed in the eastern, central, and southern Indian parts.

7.3. Types of Biodiversity

Biodiversityis deduced from the word 'biological' and 'diversity', includes the types of lifeforms form at all scales of biological network, ranging from genes to species to ecosystems. Tropical areas of the world such as- tropical rainforests and coral reefs have greatest biodiversity. Biodiversity is greatly affected by the habitat destruction, fragmentation, population decline, and loss. Further, the biodiversity is increased by the genetic and evolutionary modifications. There is a growing awareness that the level of biodiversity is a crucial factor in determining the strength of ecosystems to disruption.

Biodiversity is of three types:

1. Species diversity

2. Genetic diversity

3. Ecological diversity

7.3.1. Species Diversity:

In any geographical area, the variety of living species found is termed as Species diversity. Equatorial region is rich in species diversity. According to Biological Species Concepts (BSC), "Species is a fundamental unit of categorization and therefore, is defined as set of related individuals which can interbreed with one another and produce offspring's".Species diversity, is simply the variety of dis-similar animals.

Species are the fundamental component of biological categorization and therefore, this is the measure most frequently linked with the phrase 'biodiversity'.Approximately, 1.75 million different species have been identified, across the globe so far. Though, many classes of life forms are not thoroughly studied so far, and estimates of species numbers vary from 3 to 100 million. Specific geographical regions bear more inhabitants over others. Regions which are rich in nutrients, better climatic conditions, adequate light and sufficient rainfall display high level of diversity in their life forms. The tropical forest had greater species richness as compared to timber farm, because these areas assist more divergent floral and faunal communities besides desert and Polar Regions.

Considering the facts above, Species diversity is vital for economic, biological, social and cultural benefits. However, misuse of practises such as fishing, hunting, extraction along with the loss of habitat and fragmentation, pollution, and global climate change are the major threats to species diversity. Another reason for the biodiversity loss is the introduction of invasive species for e.g., Asian Green Mussels. Therefore, in order to preserve species diversity, natural biological resource regulation and habitat safeguarding are most important.

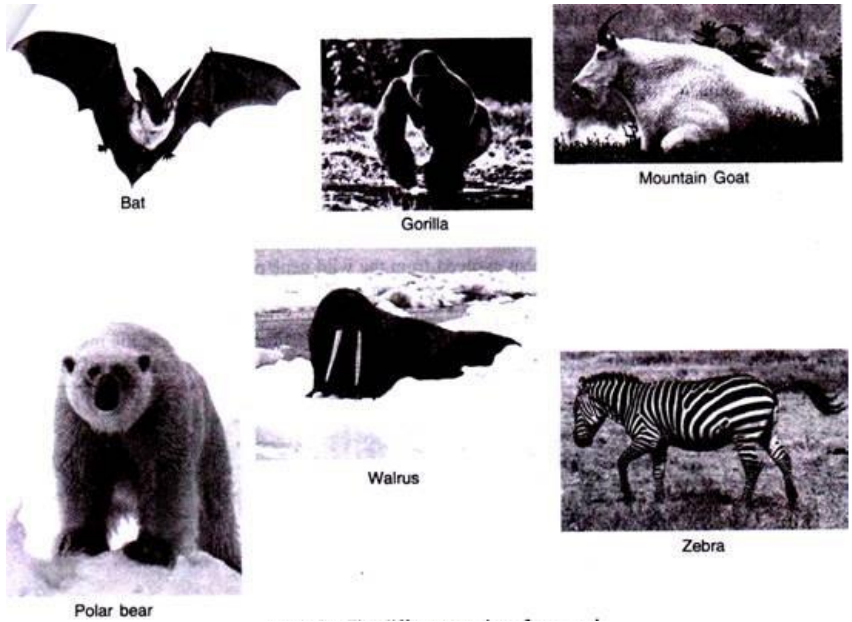

Fig.7.1: The different species of mammals.

Source-https://www.biologydiscussion.com/biodiversity/biodiversity-concept-types-and-other-details-with-diagram/7132.

7.3.2. Genetic Diversity:

Variation of genes within a species, or between individuals of the same populations or different populations is called genetic biodiversity. In more simple words, the dissimilarity among animals of the same species is genetic diversity.

This constituent of biodiversity is crucialas it permits the populations to adjust to environmental variations through the survival and reproduction of life forms within a population that have specific genetic features that allow them to resist these changes.Every individual of plant or animal species vary from other individuals in its genetic makeup.Each individual has particular set of characters, because of its genetic makeup or code.The genes occur in the individual can form indefinite number of combinations which leads to the genetic variability.Hence, we observe that each human, who is characteristic of the similar species, i.e.,*Homo sapiens,* is distinct from another. Similarly, there are many varieties within the same species such as rice, wheat, maize, apples, bananas, mangoes, etc. that differ from one another in size, shape, colour of flowers and taste of fruits and seeds due to the alterations at the genetic level.Theword 'gene pool' has been used to designate the genetic diversity in the divergent species (Fig.7.2). This also involves the wild species diversity, which through blending in nature over the years resulted in development of newer varieties. The cultivated agricultural crops and animals'varieties have also advanced from the wild gene pool.

The preservation of greater genetic diversity among individuals is, therefore, a protection and government preference as this imparts the greatest ability for any population to adjust to a wide range of environmental variations.Contrarily, failure to sustain the genetic diversity reduces the individual's capacity to acclimatize, making it exposed to even small environmental changes, thereby, increasing the chances of extinction. In the recent decades, a newly emerged field of science, named 'biotechnology' has surfaced, which modifies the genetic makeup of different species through genetic engineering to produce improved crop varieties and domestic animals.

Fig.7. 2: Genetic diversity in squirrels

Source:https://www.biologydiscussion.com/biodiversity/biodiversity-concept-types-and-other-details-with-diagram/7132.

7.3.3. Ecological/Ecosystem Diversity:

The difference between eco-systems is called as eco-system diversity and includes habitat diversity, ecological processes, water cycle and energy flow. Due to the complexity of ecological processes, biodiversity can be very hard to estimate. Though, there are some key measures of biodiversity which we can precisely and effectively detect. For coral reefs these measurescontain: diversity of seafloor, seagrass, seabirds, and mangroves, species of conservation scrutiny and species abundance and community organization of hard corals on the Great Barrier Reef's (GBR).

Each ecosystem comprises of individuals from many discrete species, living together in a geographical areabridged by the flow of energy and nutrients. The ultimate energysource for all the eco-systems is Sun. Plants transform sun's radiant energy to chemical energy, which in turn flows via several networks when living beings eat the plants and then are eaten by other animals. Bacteria and fungi obtain energy from the decaying dead creatures, liberating nutrient back into the soil. An ecosystem, thus, is a group of living elements, such as- plants, animals, microbes, fungi, etc. and non-living components, such as- climate, matter and energy that are associated with energy flow.

Ecological diversity refers to the 'changeability between the plants and animals'species living together and coupled by energy flow and nutrients cycling in discrete ecological networks. It often involvesalteration within the same species and alteration among the dissimilar species of animals, plants, and microorganisms of an ecological complex. Therefore, it prevails to the affluence of flora, fauna and microorganisms surrounding an ecosystem or biotic community.

The plenty of the biosphere in terms of diverse life forms is due to the alterations in the ecosystems. The earth has a several ecosystems such as- grasslands, semi-arid deserts, forests, marine, wetland, freshwater, swamp, marshlands (Fig.7.3) etc. each having its different floral, faunal and microbial composition. Ecological diversity constitutes acomplicated network of distinct species existing in local ecosystems and the powerful interlinkage among them. The ecological diversity is of greatsignificance that has emerged and advanced over millions of generations through interplay among the several species within an ecosystem.

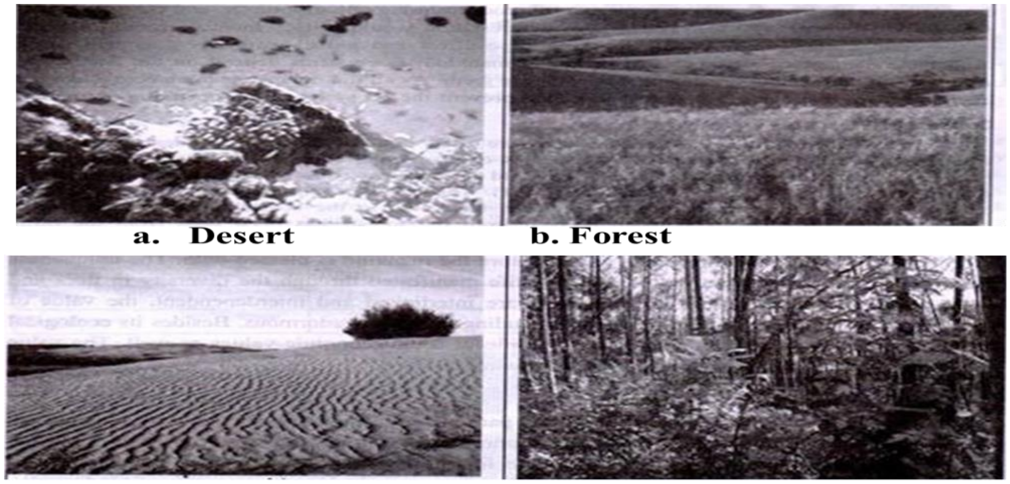

Fig.7.3.

Biodiversity in different ecosystems a) Desert, b) Forest, c) Marine Ecosystem and d) Grassland ecosystem

Source- https://www.biologydiscussion.com/biodiversity/biodiversity-concept-types-and-other-details-with-diagram/7132

7.4. Significance of Biodiversity (Biodiversity as a Natural Resource):

Biodiversity is not only essential but of great importance for mankind. It is the most valuable gift of nature to human beings. The specialty of our planet mother earth is due to the existence of life exhibited through the flora and fauna diversity.

1. Biodiversity provides many economic benefits such as diverse forms of food, timber, fibre, medicine, dyes, industrial enzymes (**Table 7.1,** Fig. 7.4, 7.5).
2. Biodiversity is the source of aesthetic and recreation values (Table 2). The beauty of our earth lies on the biodiversity, which otherwise would have resembled to the other barren planets of the universe. It adds quality of life and gives some very important aspects of our existence through the beauty of landscape.
3. Eco-system biodiversity indirectly affects ecological factors, such as soil maintenance, chemical and nutrient cycles, climatic regulation, and waste treatment.
4. Genetic biodiversity opens the way for evolutionary change and variation. Variation is important for crop improvement.
5. Diverse forms of plants are the source of important drugs for human beings(**Table7.2)**.

6. Biodiversity also promotes eco-tourismFig.7.6. People are also tempted to enjoy the beautiful natural surroundings and wildlife and no one likes to live in barren place.

Fig.7.4: Economic benefits of Biodiversity a. firewood, b. food, c. timber.

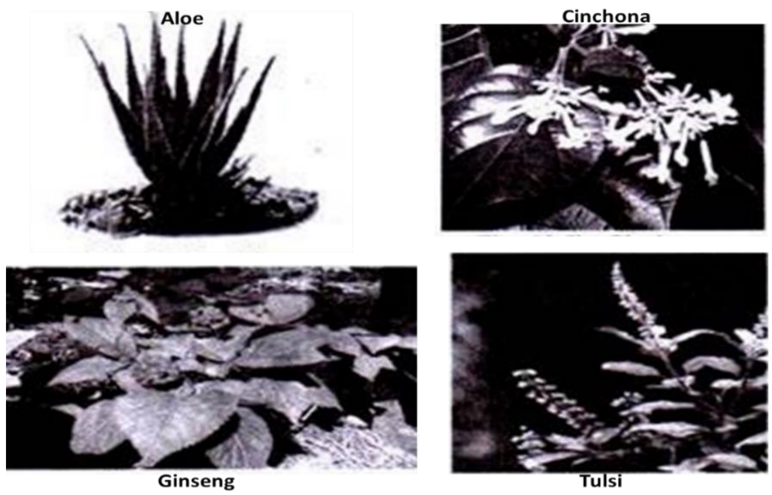

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Fig.7. 5: Medicinal benefits of Biodiversity

Fig.7. 6: Biodiversity encouraging eco-tourism

Source- https://www.biologydiscussion.com/biodiversity/biodiversity-concept-types-and-other-details-with-diagram/7132

Table:7.1: Plant parts used directly by people

Name of the source	**Part used**	**Purpose**
Tulsi (*Ocumumsanctum*)	Leaves	Cough and cold
Ginger (*Zingiber officinale*)	Stem	Sore throat and cold
Bamboo (*Bambusa*)	Stem (rhizome)	Making huts, basket etc.
Pulses (*Cajanuscajan, Vigna radiata, Vigna mungo)*	Seeds	Food, protein source, and green manuring
Mango (*Mangiferousindica*)	Fruit	Food
Neem (*Azadirachtaindica*)	All parts	Skin diseases, antiseptic
Sarpagandha(*Rauvolfia*)	Roots	Blood pressure
Sal teak (*Shorearobusta*)	Woody stem	Timber
Ishabgul (*Plantagoovata*)	Seeds	Stomach disorder
Cotton (*Gossypium hirsutum*)	Seed coat fibre	Textile
Wheat (*Triticum aestivum*)	Fruit and stem	Cereal and fodder
Vasaka (*Justicia adhatoda*)	Leaf extract	Cough
Sugar cane (*Saccharum officinarum*)	Stem	Cane sugar
Cinchona (*Cinchona sp*.)	Bark	Malaria
Amla (*Phyllanthus emblica*)	Fruit	Rich source of vitamin C and iron
Ashwagandha (*Withaniasomnifera*)	Root	Strength

Table:7.2: Drugs obtained from plant source

Drug	Plant source	Purpose
Reserpine	Sarpagandha(*Rauvolfia serpentina)*	Blood pressure control

Papain	Papaya (*Carica papaya*)	Highly digestive
Menthol	Mint	Reduce pain on local applications
Tetracycline	Bacterium	Antibiotic
Morphine	Opium	Painkiller
Caffeine	Tea, coffee	Stimulant
Quinine	Cinchona	Anti- malarial
Cocaine	Cocoa	Painkiller
Atropine	Belladonna	Painkiller

7.5.Loss of Biodiversity

The existence of human being is in danger due to loss of biodiversity. The ever-increasing population has led to the exploitation of resources and their constant decline. Increase in human population has led to the fragmentation of habitats, ecosystems and forest land. As natural habitats are being demolished for urbanisation or agricultural purpose, biodiverse forms are being destroyed, and many important florashave become lost.

India is the home of over 16,000 species of flowering trees and medicinal herbs. Out of these, nearly 6,000 species occur in the Western Ghats. The western ghats of India including Maharashtra, Karnataka, Kerala, and Goa are covered with lush green vegetation. Therefore, these Western Ghats are treasure house of many precious and valuable flora. Unfortunately, industrialization and urbanization are slowly depriving this region of its biodiversity. The varied species which are being threatened are mostly rare and valuable medicinal plants that are source of important alkaloids used in the manufacturing of life saving drugs.

In others parts of the country, like Himanchal Pradesh and Jammu and Kashmir, many precious herbs and medicinal plants have been destroyed by indiscriminate robbing of forests by pharmaceuticals companies and legal/illegal forest syndicates. Consequently, more than 1500 species of flowering plants having medicinal properties have been destroyed and many are on the verge of extinction. *Rouvolfiaserpentina*, an important medicinal plant, producing 80 alkaloids, is now exploited for use in cosmetics. Similarly, other medicinally important plants such as, *Catharanthus roseus*, yields **vincristine** and **vinblastin** for curing leukaemia; *Taxus baccata* yielding alkaloid**taxol** for cancer treatment; *Colchicum luteum* etc. are fast disappearing for their natural habitat. Additionally, North-eastern regions of India, which was once rich in orchids, have slowly been diminished, and about 20 orchid species have already been listed in the **Red Data Book** of **C**onservation of **I**nternational **T**rade in **E**ndangered **S**pecies.

Consequences of Biodiversity Loss

Biodiversity loss affects mankind in the following ways-

1. Agricultural sector is affected by loss of biodiversity.
2. Hybrid crops are more popular than their wild varieties, hence they are being neglected. Wild varieties are more resistant than the hybrids, and their extinction would affect the breeding programmes.
3. The loss of genetic diversity has resulted in the loss of cultural diversity.
4. In any ecosystem, the various ecological processes and species are inter-related and inter-dependent, and loss of any one species disturbs and disbalances the ecosystem.

The species whose presence or absence has a marked effect on the community, is known as *key stone species*.It is important to restore and conserve biodiversity for the welfare of mankind.

Factors Affecting Biodiversity

Loss of biodiversity is a natural process. Organisms are born and die. But in the last 100 years, the rate of loss of biodiversity has increased tremendously, and today more than 25,000 plant species are in danger of being extinct. The main factors that affect biodiversity are-

1. Over-exploitation of the natural environment

In the present age, the unwanted activities of man are the majorcause that gives rise to one of the great threats to the natural environment, i.e., the overexploitation of natural resources. Increasing demand for biological resources and the increase in human population across the globe, has led to the mechanical intervention towards increasing productivity. Hence, our biodiversity is exploited beyond its limit for re-establishment, which accounts for a warning to biodiversity.

2. Agriculture

Increase in population requires more land for cultivation of crops. forests, grasslands and virgin lands are cleared for agriculture and in this process, the biodiversity is destroyed.

3. Loss, degradation and fragmentation of habitats

The forest is the natural home of plants and destruction of the forest leads to the destruction of valuable flora. Destruction of their natural habitat, overgrazing by domestic animals, deforestation, industrialization, export of valuable species, mining and construction of roads, are the major reasons which led to the biodiversity loss, degradation and fragmentation of habitats.

4. Environmental pollution

Pollution due to effluents, pesticides, smog, eutrophication kills the sensitive species.

5. Introduction of invasive species

Entry of new species invades a new area and can wipe out the old species. For e.g.- *Eichhornea crassipes* invades lakes and rivers and wipes out the old existing species.

6. Effects of climate change and natural reasons

Increase in the surface temperature of the aquatic environment leads to the changes in the growth, development, reproduction and feeding patterns of the population. On the other hand, the aridization of the territory in the terrestrial environment, influenced by a water scarcity, leads to the changes in the ecosystems and the extinction of biodiversity they harbour. Natural reasons such as- eruption of volcanoes, frost and landslides, excessive rainfall/drought, forest fires, disease epidemics leads to slowly wipe out plant species. When volcanoes erupt, the hot lava flowing out completely destroys the habitat. Similarly, extreme frost conditions kill the life forms before they can complete their life cycle. Also, excessive drought or rain perishes the habitat of both plants as well of the animals.

7.6. Biodiversity Hotspots

The geographical locations that are rich in species diversity are called hotspots of biodiversity. The flora and fauna of the world are not uniformly distributed throughout. Some areas have larger number of species and are known as megadiversity zones. The countries having such zones as called as megadiversity countries(12 in number). India is also one of the diversity rich countries and is home to 8 percent of global species diversity.The rainforest in the Amazon Basin is the most famous hotspot of biodiversity. It houses greater than 10,000 plants species, 2,000 bird species, and around 400 mammal species. Other major hotspots are- rainforests of Southeast Asia, the African savannahs, and the coral reefs of the Pacific and Caribbean.

In 1988 Norman Myers established the **concept of hotspots** *in-situ* conservation. According to him "These hot spots are the richest most threatened reservoirs of plant and animal life on earth". To qualify as biodiversity hotspot, a region must meet two strict criteria:

1- The number of endemic species found- endemic species are those flora and fauna which are originated only in that particular region and nowhere else. There should be at least 1500 vascular plants as endemics.

2- The loss in habitat- it denotes the degree of threat to that hot spot. It must have 30% or less of its original natural vegetation.

7.6.1. Hotspots in India

There are 25 hot spots all over the world, allocated amongst 12 nations. India has four hot spots- the Western Ghats, the Eastern Himalayas, the Indo-Burma region, and the Sundaland (Includes Nicobar group of Islands).

The Western Ghats

The Western Ghats includes the western coast of Indian peninsula. The ever green and semi- evergreen forests are inhabited by endemic species of flora and fauna. The two major biodiversity centres are-

1- The **Amambalam Reserve**

2- The **Agasthyamalai hills** and the **Silent Valley**.

The Eastern Himalayas

The Eastern Himalayas extends over north eastern India and Bhutan is extremely rich in endemic species. Primitive angiosperm families, like- Magnoliaceae and Winteraceae, and primitive genera, such as *Magnolia*, *Betula*, *Orchids* occur in this area.

Indo – Burma Region

Extended over a range of about 2,373,000 km², almost six large species of mammals have been identified in the Indo-Burma Region so far, over the period of 12 years. These species include-the Large-antlered Muntjac, the Annamite Muntjac, the Grey-shanked Douc,the Annamite Striped Rabbit, the Leaf Deer, and the Saola.This hotspot is even well known for the indigenous species of freshwater turtle, the majority of which are endangered with disappearing, due to over-use and immense habitat loss. Bird species such as- threatened White-eared Night-heron, the Grey-crowned Crocias, and the Orange-necked Partridge are also found in the Indo-Burma Region, which is also home to 1,300 different bird species.

Sundaland

The Sundaland hotspot encloses Thailand, Indonesia, Singapore,Malaysia, and Brunei and resides in the South-East Asia region.United Nations announced the Sundaland as a World Biosphere Reserve, in the year 2013. The Sundaland is popular for its wealthy terrestrial and marine ecosystems and is one of the prosperous biological hotspots across the globe which encompasses 25,000 vascular plants species, out of which 15,000 species are located in this area only.

7.7.Summary

Biodiversity is a combination of words that consist of not only the types of dissimilar animals (species diversity) but also the variability among animals of the same species (genetic diversity) and between ecological communities (ecosystem diversity).It gives the idea of the number of distinct life forms and their relative frequencies in an ecological community. It incorporates the network of life forms at various levels extending from total ecosystems to the chemical elements, which shape the molecular foundation of genetics and heredity. Therefore, the sum total of all the varieties, genes,species, populations in distinct ecological communities and their relative abundance is considered as biodiversity.

Scientistsand environmentalists are conscious about the huge prospects of several different organisms living on this planet earth. Our planet earth's necessity and utility rely solely on the natural resources. Biological resources supply nourishment, clothing, housing, fuel, medicine besides meeting our numerous other requisites. Thus, the awareness of biodiversity is of huge advantage in programming feasible livelihood and preserving biological resources.

Species biodiversity refers to the biodiversity at very basic level and is the abundance species found in any geographical area or in a given biological organisation (population, ecosystem, Earth). It comprises of total earth's species extending from plants such as- bacteria, viruses, fungi, algae, bryophytes, pteridophytes, gymnosperms, angiosperms together with all the animal species constituting unicellular protozoans to mammals.Genetic Diversity is the diversity of genetic features (expressed or recessive) within a species. The genetic variance is important for healthy reproducing individuals, the depletion in genetic variablenessbetween breeding individuals results in inbreeding that in turns can cause species extinction.On the other hand, ecosystem diversity can be explained as the types of distinct habitats, communities and ecological systems. A biological community is determined by the species that inhabit aspecific area and the interconnectionsamong those species. A biological community jointly with its related physical territory is termed an ecosystem.

A biodiversity hotspot is a geographical region having high species concentration which is endangered with loss. Hotspots are mostly observed in tropical or subtropical parts of the world. Biodiversity hotspots are important for a flourishing ecosystem. Biodiversity is the base of all life forms on Earth. If there were no species, there would be no air to respire, no edibles to consume, and no water to sip. There would be no human civilization at all. The co-occurrence of life and naturalresources is vital for the whole ecological life support network. According to Conservation International, a geographical region must attain the following two standards to certify as a hotspot:

- The area should have not less than 1500 vascular plantsspecies i.e., it must have anabundance of endemism.
- It must hold 30% (or less) of its indigenous habitat, i.e., it must be threatened.

8.Terminal questions

Q.1: What do you understand by biodiversity?

Answer:---

Q.2: What do you understand by loss of biodiversity?

Answer:---

Q.3: Discuss the causes and consequences of biodiversity loss.

Answer:--

Q.4: Write the Differentiate between

a- Species and Genetic diversity

b- Genetic diversity and Eco-System diversity

Answer:--

Q.5: Briefly explain

a- Hot spots of biodiversity

b- Different types of biodiversity

Answer:--

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8. Further suggested readings

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Unit-8: Biodiversity Conservation

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8.1. Introduction

Preservation of all life forms is known as Biodiversity conservation. This involves saving species and ecological community, which in turn enhance its quantity and standard. On other words, Biodiversity conservation is the safeguarding and biodiversity regulation to secure resources for rational development, which has three main goals- to preserve the diversity of species, sustainable usage of species, and sustainable implementation of ecosystem. For this purpose, appropriate conditions are required. Countless living beings on our planet earth are the main wealth of the creation and world and thus it is our responsibility to save it. Biodiversity protection is crucial to warrant their presence and survival for enhancing genetics. Hence, its conservation is vital for upcoming generations. The requirements of biodiversity protection are- preserving the survival of all life forms, resources sustainability, encouragement of natural site, equilibrium in natural process, socio-economic advancement, study and research fields.

The in-situ technique of protection/conservation is performed in real territory or habitat, which includes national parks, biosphere reserves, sanctuaries, sacred forest and lakes. On the other hand, ex-situ means of protection/conservation is done on artificial or man-made environments or domain, which contain germplasm, gene bank (DNA bank), seed bank, botanical gardens and zoos.

Tribal or indigenous (Traditional) knowledge related with biological resources is an inseparable and appreciable part of resource altogether. Indigenous knowledge has the possibility of being transformed into trade interests and making profits by their guidance for the development and expansion of beneficial items and processes, which would in turn save time, money, in addition to the establishment of modern biotech industry into scientific research and product development. Thus, benefits must be shared and provided to founders, originators, and owner of indigenous knowledge. Only novel information could be patented, which is applied to innovation but not to current knowledge.

Objectives

- To discuss Conservation of natural biodiversity
- To discuss the need to conserve biodiversity
- Biodiversity Conservation Methods
- Convention on Biological Diversity (CBD)

- ➢ Strategies for Biodiversity Conservation

8.2. Conservation of natural biodiversity

The protection and management of the biosphere so that it may give maximum benefit to the present generation, as well as maintain it for the coming generation, is termed as biosphere conservation. Protection of the natural areas, promoting sustainable practices, and the restoration of degraded lands are some of the practices to conserve biodiversity.The biodiversity conservation is important for a numerous of reasons.

1. It is compulsory to sustain the ecosystems which provide us with necessary services, like fresh air and clean water.

2. Several medicinal plants across the globe come from biodiversity hotspots, and therefore, it is crucial to preserve these regions in order to make sure that new drugs remain in existence.

3. Biodiversity is necessary for travel and tourism, and many people visit parks, sanctuaries, zoos, and reserves to see the beautiful display of plants and animal species that exist there.

4. Finally, it is ethically incorrect to exploit species for no particular reason, and we do not require doing so.

8.2.1. Need for Biodiversity Conservation

The planet's biodiversity is in danger. Species are vanishing at a rapid rate, and more ecosystems are on verge of becoming extinct. The biodiversity loss has significant repercussions for humans. It will lead to food chain disintegration, declining ecosystem which supplies vital services like purification of water and climate control and limits the crops and livestock biodiversity.

Biodiversity Conservation is important as it provides several economic and social benefits and helps in maintaining natural balance of the environment. Biodiversity loss can further, lead to the loss of beneficial natural resources, and can result in the species extinction. Every individual should make an effort to protect and conserve the biodiversity for the welfare of mankind. India is the home to about 45,000 species of plants and 81,000 species of fauna; hence a broad-spectrum conservation strategy is needed.

Biodiversity is also playing a very important role for human pleasure, relaxation and amusement. It is accountable for the beauty of the wild life, and bestows good time for hiking, bird watching, and other different types of outdoor recreation. Humans should do something to secure biodiversity if we desire to establish a flourishing and sustainable future for our own selves and for upcoming folks.

8.3. Biodiversity Conservation Methods

There arenumerousapproaches that can be used to help conserve biodiversity. Some of the most common methods include–

- Preserving habitats
- restoring habitats
- reducing habitat destruction
- promoting sustainable use of resources
- educating the public

8.4. Convention on Biological Diversity (CBD)

The Convention on Biological Diversity (CBD) is an agreement which was approved in 1992 to preserve biodiversity. This agreement has three main objectives:

1. To conserve of biological diversity
2. The sustainable utilization of biodiversity components
3. The fair and unbiased distribution of the profits emerging from the use of genetic resources

The CBD is one of the most effective and successful treaties ever, and is endorsed by over 190 countries. CBD strives to accomplish its objectives by making national biodiversity strategies. A national biodiversity strategy (NBS) is a document that shapes how a country will protect, conserve and control its biodiversity. It generally involves the record for conservation of priority areas and necessary actions that need to be taken to attain conservation objectives. The CBD also inspire countries to create regional and international biodiversity policy.

8.5. Strategies for Biodiversity Conservation

The biodiversity conservation strategies comprise-

1. Set up protected areas: Protected areas are land or water areas which are set apart and controlled particularly for biodiversity protection.
2. Checking loss of habitat and deterioration: Habitat loss and deterioration are the two key warnings to biodiversity. Habitat loss takes place when aregion of habitat is disturbed, while habitat degradation (deterioration) happens when a habitat area is harmed, making it less desirable for wildlife.
3. Encouraging rational or sustainable utilization of natural resources: Sustainable use of biological resources means using assets in such a way that does not leadsto environmental destruction.
4. Promoting the genetic diversity conservation: Genetic diversity is the variety of genes among a species. It is vital for the survivorship of a species, as it permits for adjustment to fluctuating environmental circumstances.
5. Nurturing the species conservation: Conservation of species is the safeguarding of individual species from loss or havoc.
6. Addressing the climate change issue: Climate change is a worldwide worry which is causing a disastrous consequence on biodiversity. It is important to address climate change for the sake to preserve biodiversity.An outline of the conservation methods for protecting Biodiversity is given below in Fig.8.1.

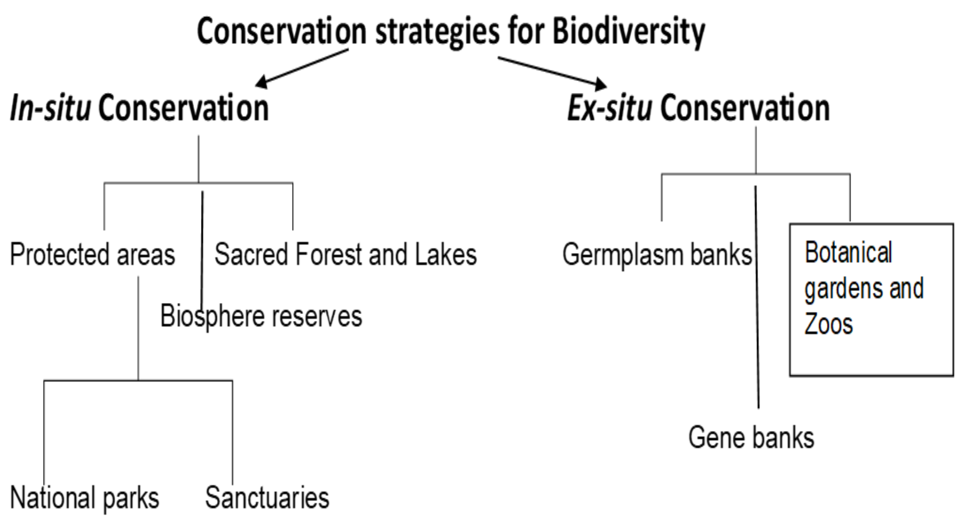

Fig.8.1: Conservation strategies of Biodiversity.

8.5.1. In-situ Conservation

The conservation of biodiversity in their natural habitat, i.e., in their home is known as *in-situ* conservation. The home of flora and fauna is the ecosystem, as such if we protect the ecosystem, the biosphere will be protected. The various methods adopted are-

i. Protected Areas

These are natural or man-made areas, particularly meant for the protection, conservation, and maintenance of the biosphere in their natural ecosystems. These protected areas have several advantages such as-

- Maintaining the habitats of the flora and fauna,
- Maintaining and increasing the population of all the species,
- Conservation of genetic diversity of the species,
- Prevention of the entry of unwanted species
- Helping the species to adjust to environmental changes

These protected areas may be in the form of –

ii. National parks

An area having indigenous flora and fauna and which is reserved for their conservation is called as *National Park*. In a national park, visitors are permitted, but private ownership, cattle grazing, social forestry, shooting, cultivation or habitat destruction is prohibited. Shooting of wildlife is a punishable offence. In India, the **Jim Corbett National Park** was the first national park. There are about 73 national parks, of which some important national parks are listed below in table 8.1.

Table:8.1: Few most important national parks of India

S. No.	Name	Place	Species
1	Gir National Park	Junagarh, Gujarat	Asiatic lion, cheetah, sambhar,

			ghariyal etc.
2	Nanda devi National Park	Uttarakhand	Snow leopard, snow pigeons, brown and black Himalayan deer etc.
3	Kanchenjunga National Park	Gangtok, Sikkim	Snow leopard, Himalayan black deer, blue sheep etc.
4	Nagerholi National Park	Karnataka	Elephant, cheetah, leopard, cheetal etc.
5	Bandipur National Park	Mysore, Karnataka	Indian elephant, cheetal, leopard, cheetah etc.
6	Banerghatta National Park	Bangalore, Karnataka	Elephant, sloth bear, barking deer etc.
7	Hazaribagh National Park	Jharkhand	Sambhar, cheetah, neelgai, leopard etc.
8	Gundi National Park	Chennai, Tamil Nadu	Cheetal, black bug, snakes etc.

iii. Sanctuaries

An area which is reserved for the conservation of birds and animals only is known as*Sanctuary*. In asanctuary**,** private ownership, collection of minor forest products, tourists are permitted, but without disturbing the wildlife and ecosystem.There are about 492 sanctuaries in India, of which some important sanctuaries are listed below in table 8.2.

Table:8.2. Some famous/important sanctuaries of India

S. No.	Name	Place	Species
1	Govind Pashu Vihar	Uttarkashi, Uttarakhand	Brown and black Himalayan bear, snow leopard, Kasturi deer etc.
2	Rajaji Abhyaranya	Saharanpur, U.P.	Elephant, cheetah, leopard, sambhar, cheetal etc.
3	Kisanpur Wild Life Sanctuary	Lakhimpur-Kheri, U.P.	Cheetah, leopard, sloth-bear, neelgai, etc.
4	Ranthambore Wild Life Sanctuary	Jaipur, Rajasthan	Cheetah, leopard, wild cat, sambhar, cheetal etc.
5	Gautam Buddha Wild Life Sanctuary	Gaya, Bihar	Barking deer, cheetal etc.
6	Lakhwa Wild Life Sanctuary	Navgaon, Assam	Rhinoceros, neelgai, cheetal, swamp-deer etc.
7	Abohar Wild Life Sanctuary	Punjab	Black deer, birds etc.
8	Nal Sarovar Bird Sanctuary	Gurgaon, Haryana	Water birds-starks, flamingoes
9	Rangthitto Bird Sanctuary	Maharastra	Storks

10	Itagiki Wild Life Sanctuary	Nagaland	Cheetah, leopard, tiger, elephant etc.

iv. Biosphere Reserves

Biosphere Reserves are a special region of protected areas of land or coastal ecosystem, which includes the flora, fauna, and natives of that area. The formation of Biosphere Reserves was proposed under Man and Biosphere (MAB) programme. There are 18 Biosphere Reserves in Indiaof which twelve are part of World Network of Biosphere Reserves based on the UNESCO Man and Biosphere (MAB) Program list(Table 8.3). In India, Nilgiris was the first Biosphere Reserve, established in 1986.

Table:8.3: Biosphere Reserves of India

S.no.	**Name**	**States/UT**	**Year**
1	Nigiri Biosphere Reserve	Tamil Nadu, Kerala and Karnataka	2000
2	Gulf of Mannar Biosphere Reserve	Tamil Nadu	2001
3	SunderbansBiosphere Reserve	West Bengal	2001
4	Nanda devi Biosphere Reserve	Uttarakhand	2004
5	Nokrek Biosphere Reserve	Meghalaya	2009
6	Pachmarhi Biosphere Reserve	Madhya Pradesh	2009
7	Simlipal Biosphere Reserve	Odisha	2009
8	Great Nicobar Biosphere Reserve	Andaman and Nicobar Islands	2013
9	Achanakmar-Amarkantak Biosphere Reserve	Chhattisgarh, Madhya Pradesh	2012
10	Agasthyamalai Biosphere Reserve	Kerala and Tamil Nadu	2016
11	Khangchendzonga Biosphere Reserve	Sikkim	2018
12	Panna Biosphere Reserve	Madhya Pradesh	2020

Importance of Biosphere Reserves

The significance and uses of Biosphere Reserves aregiven in Fig.8.2.

a) **Conservation of ecosystem**.

b) The establishment of biosphere reserve ensures that the local ecosystem- flora and fauna and genetic resources will be protected and conserved.

c) **Promoting sustainable development**.

d) The biosphere reserves help in promoting cultural, social, ecological, and economic sustainable development.

e) Scientific development

f) The biosphere reserves provide an area for research programmes, wildlife monitoring programmes and information exchange Centre for local, national and international issues.

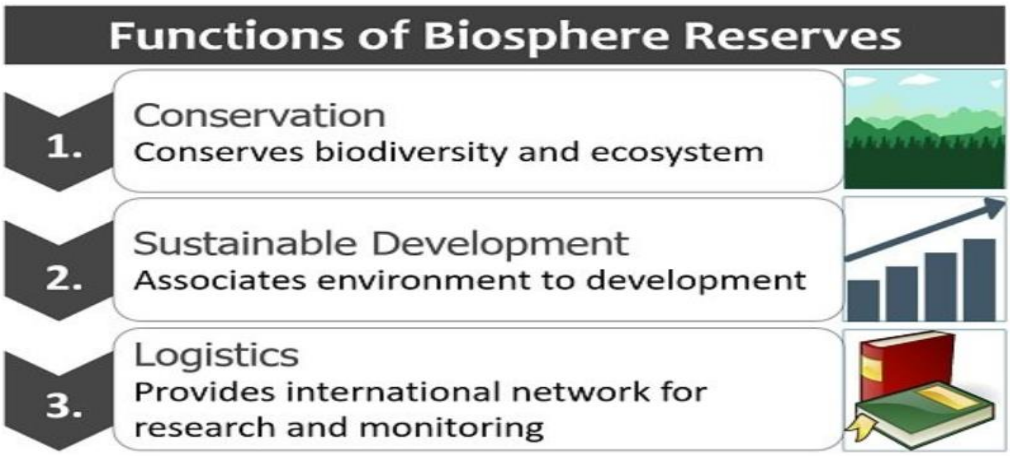

Fig.8.2: Functions of Biodiversity.

Source: https://biologyreader.com/biosphere-reserves.html

Structure of Biosphere Reserves

A Biosphere Reserve is divided into three zones (fig. 8.3).

a) Core zone

It is the central innermost zone consisting of natural ecosystem. It is absolutely undisturbed and legally protected zone.

b) Buffer zone

The intermediate zone, protecting the core zone. In this zone various human activities, related to the biosphere, takes place, such as educational programmes, research, experimental work etc.

c) Transitional zone

This is the outermost, semi-protected area, in which the local people actively participate and co-operate with the biosphere reserve management in the conservation programmes, such as social forestry, cropping, horticulture etc.

d) Restoration zone

Outermost degraded land area which is selected for restoration to natural conditions.

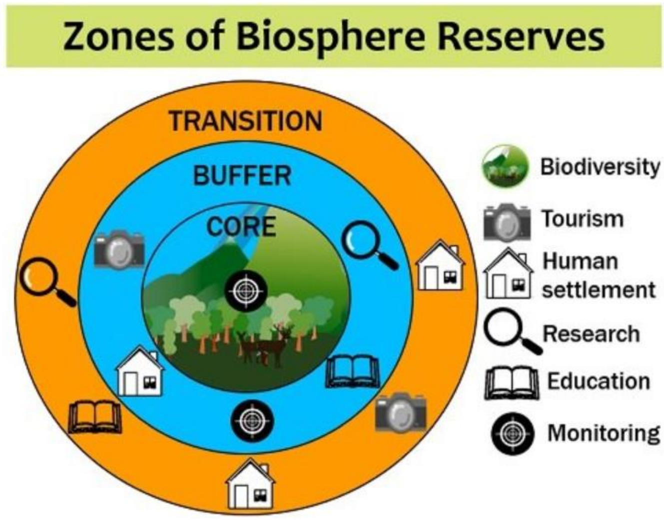

Fig.8.3: Pictorial representation of biosphere reserve zones.

Source: https://biologyreader.com/biosphere-reserves.html

1- Sacred Forest and Lakes

Some forest and lakes are regarded as sacred, due to religious beliefs and are protected by the tribals and local people. These sacred forests and lakes are completely undisturbed biotic interference, and represent a classic example of Biodiversity conservation for e.g., Pushkar lake (Ajmer), Silent valley (forest) of Kerala, Khecheopalri lake in Sikkim, Sacred forest in Shillong, Meghalaya etc.

8.5.2. Ex-situ Conservation

The conservation of biodiversity in places removed from their natural habitats is known as *ex-situ* conservation. This is brought about by the following methods.

i. Germplasm banks

This is the most effective method of conserving flora and fauna, via storing the germplasm at low temperature (-196°C in liquid nitrogen). The technique is called as

cryopreservation. Seeds, pollen, embryos, tissue cultures can be conserved by this technique. The **C**onsultative **G**roup on **I**nternational **A**gricultural **R**esearch (CGIAR) has established several gene banks, having an *ex-situ* collection of 60,000 crop gene pools. The world bank and WHO (World Health organization) are also supporting various programs on germplasm conservation.

ii. Gene banks or DNA banks

Gene or DNA are centres, where the DNA fragments of the entire genome of any organism is stored and preserved.

iii. Botanical gardens and Zoos

Botanical gardens are developed to grow plants (trees, shrubs, or herbs) from all over the world, e.g., Lalbagh Botanical Garden, Bengaluru, National Botanical Garden (Lucknow), Acharya Jagdish Chandra Bose Botanic Garden, Sibpur (Kolkata), Lloyd Botanical Garden, Darjeeling, Royal Botanic Garden, Kew (England). Zoos are the *ex-situ* homes of birds, reptiles, amphibians, and mammals, kept in cages or in free condition. The animals are protected, taken care of and allowed to breed for increasing their population.

Advantages of *Ex-Situ* Conservation Include

The major benefit of ex-situ conservation is that it permits species protection even when they are not cultivated. This is crucial because the species which are on the extremity of loss can be rescued. Moreover, ex-situ conservation grants investigators to study, examine, analyze, and master more about the species which are threatened or endangered.

Role of Local Communities and Traditional Knowledge in Conservation

Provisions of protection of biodiversity, including bio-resources such as- forests, water bodies, and agro-ecosystems, are acknowledged as an important subject matter fascinating the need of sustainable protection by means of “Traditional Knowledge”. Traditional knowledge plays an immense role in the conserving the biodiversity, which is getting eroded and constantly declining at a rapid rate due to remarkable growth and capitalism.

8.6. Traditional Knowledge

Traditional Knowledge or indigenous knowledge and local knowledge mostly refer to the practices and innovations embedded in the traditions of indigenous, or local communities all over the world for the welfare of the various goals.

Fig.8.4: Representation of promoting traditional knowledge

Source:https://www.kashishipr.com/blog/traditional-knowledge-and-conservation-of-biodiversity/

Traditional Knowledge is culturally oriented, transferred and expanded from generations to generations and is used by ancient times by tribal people which help to make the country more developed (fig. 8.4). Traditional knowledge is divided into-

- Cultural knowledge
- Artistic knowledge
- Medicinal knowledge
- Agricultural knowledge
- Biodiversity knowledge
- Sacred knowledge

8.6.1. Characteristics of Traditional knowledge

It is also often referred to as ethno science, i.e., the 'stock of knowledge,' comprising "systems of concepts, beliefs and ways of learning." This form of knowledge is accumulation of collective experiences, which are gained over the centuries and gradually adapted to the topographical and cultural needs. The mode of transmission is usually oral, and, therefore, it tends to take the form of stories, songs, folklore, proverbs, cultural values, beliefs, rituals, community laws, the local language, and agricultural practices, including the development of plant species and animal breeds. Few important features of indigenous knowledge are as follows-

1. In many cases, transmitted from generation to generations
2. Transmitted verbally from individual to individual
3. It is regarded as nature's gift or god's gift not a private property
4. Original developer of information is impossible to identify
5. Usually linked to biological resources and intimate part of cultural life of local communities.
6. It is not limited to particular area of technology or arts.

Its importance lies in the truth that can be applied in nature, specifically in the areas such as-health sector, fisheries, agriculture sector, horticulture, forestry, and environmental regulation mostly. Since these knowledge networks are formed through gradual growth and dissemination, they frequently result in the development of spatial-temporal awareness, which are of huge value to direct and execute the measures for biodiversity.Hence, traditional knowledge can assist and impart in the waysmentionedbelow:

1. Determine the benchmark to compute the present state of biodiversity, ecosystem services, and cultural well-being;
2. Build diversified approach to establish different levels of management arbitrations to reverse biodiversity diminish; and
3. Set goals and meet the aim as per the recovery rate.

8.6.2. How traditional knowledge assist in conserving the biodiversity?

Indigenous knowledge has also been found useful for ecosystem restoration and it often embraces the elements of adaptive management. Further, these knowledge networks play significant role in -

1. Conserving and safe guarding biodiversity
2. Nurturing ecosystem services
3. Re-establishment of tropical, ecological and bio cultural
4. Rational water management
5. Conservation of genetic resource

6. Other biological resources management

The culture is making efforts to reacquire its ancient ways. Thus, presently, this traditional knowledge is not only playing significant role for the tribal communities but also for the current agriculturalists and industrialists as many of the products in today's world are plant-oriented medicines, health items, cosmetics, including other items such as-handicrafts, and agriculture products. Additionally, indigenous knowledge bestows remarkably towards sustainable advancement as many of these communities are found in the areas where earth's extensive genetic resources are present. Many of the tribal practises have been proven to increase, strengthen, amplify, upgrade and boost biodiversity at the local level and assist in the continuance of a robust ecosystem. Nevertheless, the contributions of local and tribal communities towards the protection and sustainable biodiversity uses, excel their importance as biological resources supervisors. Their expertise and methods impart beneficial guidance to worldwide and assist propose useful models for various biodiversity schemes. Moreover, as on site-groups with substantial understanding of local environments, tribal and indigenous groups are more openly and accurately implicated with preservation and sustainableapplication.

8.6.3. Practising traditional knowledge

1. Let us consider a few examples where tribal knowledge has helped notice the prospects of biodiversity and the conservation thereof.
2. Application of neem when we suffer from fungal infection on skin, and application of neem as toothbrush.
3. Application of turmeric paste on the wound after getting hurt.
4. Use of basil leaves for cough and cold.
5. Use of lemon or ginger for indigestion or stomach ache.
6. Snake bites and scorpion's bites are cured from roots and plants.
7. Spotted House Snake and Yellow-bellied House Snake has been conserved as they prey on rodents, where food is stored.

8. Due to the poisonous effects on mucous membrane, the Moomang plant is not recommended for household curation

9. Birds like Greywing Francolin (Khoale), Rock Kestrel (Seotsanyane and Bald Ibis (Mokhotlo) have been protected for their important role in food chain.

10. A modern drug has been manufactured from the semi-aquatic herb *Bacopa monnieri* that has been indigenously used for increasing memory power in India.

11. It shows how the very existence of cultural diversity is directly dependent on biological diversity.

8.6.4. Protection of traditional Knowledge

As the commercial progress is enhancing the developed nations are using the biological resources and its component of these indigenous people without giving fair compensation and taking their permission. When these practices are followed unlawfully, it is called **bio-piracy**. Indian biological resources which are patented in the developed countries for their commercial benefits and is strictly the matter of **bio-piracy**. The Indian government needs to protect these resources of tribal communities from these national for commercial gains.

Global initiative: Confluence of Biodiversity and Traditional Knowledge

Source- https://www.kashishipr.com/blog/traditional-knowledge-and-conservation-of-biodiversity/

At the global level, the concourse and interconnection of traditional (indigenous) knowledge and biodiversity conservation are indicated in the Biological Diversity convention

(CBD). The convention in its foreword itself addressed that the conservation and sustainable use of biodiversity is possible by the use of traditional knowledge.

The particular evidence is displayed in Article 8(j), which declares that each contracting party shall, to a certain degree and as relevant:

"Subject to its national legislation, respect, preserve and maintain knowledge, innovations, and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and promote their wider application with the approval and involvement of the holders of such knowledge, innovations, and practices and encourage the equitable sharing of the benefits arising from the utilization of such knowledge, innovations, and practices."

With specific mention to Article 8(j), the Conference of the Parties has initiated a working group in advancement of pursuing the goal declared therein. The said group is available to all parties, and all indigenous, tribal and local communities are permitted to offer their contributions. In advancement of meeting the objectives of the Convention, many governments are seeking national diversity plans, projects, schemes, and programs via either exclusive laws or administrative orchestrations.

Other than the earlier mentioned features, Agenda 21 has also been granted within Principle 22, which states that local (indigenous) people have animportant role to play in environmental control and expansion because of their ancestral traditional knowledge and practices. The United Nations has also appreciated the role of traditional knowledge role in conserving biodiversity through various initiatives, such as- the United Nations Development Program and World Bank.

8.6.5. Concluding Remarks

In view of the international objectives and simultaneous requirement to realize and support the aspects of traditional knowledge, governments and other parties can follow the following routes:

1. Indigenous groups should be a part of decision making and policy designing besides having role in conveying their traditional knowledge.

2. Governments, parties, and locals should preserve, maintain and strengthen their traditional knowledge regarding the protection and rational use of the biodiversity.
3. Allotting tribal rights to land occupancy, acquiring resources, and nourishing cultural righteousness can be helpful.
4. To preserve biodiversity sustainably, we require comprehensive and integrated knowledge networks, involving both traditional and modern systems.
5. Unbiased distribution of welfare emerging from making use of this traditional knowledge should be nurtured by government.

8.7. Summary

The tradition of preserving the natural surroundings and its biological richness is biodiversity conservation. This comprises of preserving the genetic alteration, ecological communities, and the terrains. Concerning this, the conservationists usually encourage the rational utilization of natural resources and communal training or education to accomplish their target.

The protection of biological resources inside their native habitat is referred to as *in-situ* conservation, which involves plant and animal diversity conservation, their ecological networks and systems that assist them. It is usually termed as "on-site" or "in-place" conservation. In "ex-situ" protection the species are conserved or preserved outside their original habitats and it includes the movement of hereditary material away from the site where it is located.

Since biodiversity protection is not an isolated or hidden matter and it affects the whole civilization when comprehensively viewed, tribal knowledge should not be applied only for regional growth, rather it should be implemented to integrate the various knowledge networks to complement each other for application at the global level. This would in turn, help in development of scientific thinking in line with indigenous or local knowledge. Therefore, this would provide value, chance, self-reliability, and empowerment for local communities along with the sustainable use of biological resources.

8.8. Terminal questions

What are the strategies for Biodiversity Conservation?

Q2- Why is conservation of biodiversity important for sustainable development?

Q3- Briefly explain-

a- Germplasm banks

b- Protected areas

c- Biosphere reserves

Q4- Differentiate between-

a- *In situ* and *ex situ* conservation

b- National parks and sanctuaries

Q5- what is traditional knowledge and how it will help in conserving biodiversity?

8.9. Further suggested readings

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Unit 9- Biodiversity Assessment

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9.10. Further suggested readings

9.1. Introduction

Humans give importance to biodiversity for a numerous reason which compel them to assess it constantly. Indeed, several biologists accept that biodiversity has innate and intrinsic worth, which means that every species has an importance and a right to survive regardless of fact that whether or not they're providing value to human community. The five main advantages of biodiversity to humans includes-economic value, ecological life support, and recreation, cultural conservation,scientific value. There are several mathematical ways to calculate and analyse biodiversity and examine the species diversity in distinct areas. The examination of species diversity is referred as species richness. The **alpha diversity** includes the species variation observed in a specific location or ecosystem. It is generally expressed in the terms of number of species found in that particular location. **Beta diversity** usually refers to the assessment of diversity of species between two or more ecosystems. On the other hands, **Gamma diversity** is analysing overall diversity for distinct ecosystems in an area. The influence of habitat degradation not just damage natural species and indigenous communities but human societies as well. Due to soil erosion, desertification, deforestation, and depletion of nutrients degraded lands are being routinely lost. Natural disasters are one of the important causes of habitat fragmentation. Processes like river flood can generate natural barriers, avoiding animals from over passing one side to the other. But, frequency of territory fragmentation has developed suddenly due to the human activities, such as deforestation mainly. Because of advancing demands for food and other purposes we source wood by transforming land for livestock and farm practices. Though most of the forest harvesting currently is well-controlled with many industries acquiring sustainable logging practises, but still, these have adverse effects on the ecosystem and surroundings. Even though the smallest habitat loss or fragmentation can have negative influence on the biodiversity.Pollution is major driving force behind the alterations across all the ecosystems, with specifically disastrous consequences on the freshwater and marine territory. Several different sorts of pollutants such as- chemical, air, water, soil, and noise are enhancing, with adverse, effects on surroundings or ecosystem. Greenhouse gas release, farm fertilizers, waste from plastics, oil poured out, and several other modes of pollution have very adverse influence on the land, soil, freshwater bodies, seas, oceans, and environment in which life forms lies on. Extreme sound, light, and pollutants primarily or incidentally put several species and human health and well-being both at risk. According to the U.S. Endangered Species Act, greater than 430 species were remarkably affected by pollution. The application of pesticides diminishes the prevailing biodiversity in the soil. Enhanced soil quality could be achieved by not using the chemical substance, along with the added impact on the soil that greater organic matter permits for enhanced water retention. In view of the above, following objectives are mentionedbelow.

Objectives

- To discuss identification and measurement of biodiversity
- To discuss Biodiversity at Local, National and Global Level
- To discuss the impacts of pollution
- To discuss the impact of pesticides on biodiversity

- To discuss habitat destruction of biodiversity

9.2. Identification of biodiversity

Identification of biodiversity refers to the process of recognizing, classifying, and cataloguing various species of plants, animals, and microorganisms present in a given ecosystem. It involves the identification and documentation of different species, their characteristics and interactions within their habitats. The primary goals of biodiversity identification are to understand the variety of life forms on Earth, assess the health of ecosystems, and aid in conservation efforts.

a) Taxonomic Keys:

These are dichotomous keys or identification guides that help identify species based on a series of choices. They typically present a set of paired statements or questions that guide the user to the correct identification.

b) Field Guides:

Field guides are books or digital resources that provide descriptions, illustrations, and other relevant information about different species. They often include details about physical features, habitats, and distribution, aiding in species identification in the field.

c) Morphological Characteristics:

Morphological characteristics, such as leaf shape, flower structure, or body shape, can aid in species identification. This approach is commonly used in botany, entomology, and zoology. For example, identifying different tree species based on their leaf shape or distinguishing butterfly species based on wing patterns.

d) Molecular techniques

Molecular techniques play a crucial role in biodiversity identification and research by analyzing the DNA or genetic material of organisms. These techniques allow for precise species identification, assessment of genetic diversity, and understanding evolutionary relationships. Here are some molecular techniques commonly used for biodiversity identification, along with examples:

- **DNA Barcoding:** This method involves analyzing specific regions of an organism's DNA to identify and distinguish between species. DNA barcodes are unique genetic markers that can be used to differentiate species accurately. It involves comparing the DNA sequences of a standardized gene region, known as the barcode region, which is typically a short segment of the genome. DNA barcoding is particularly useful for species identification when traditional morphological characteristics are challenging to observe or distinguish, such as with cryptic species or specimens in different life stages. It also allows for rapid and accurate identification of species, including those that are difficult to identify based solely on physical characteristics. DNA barcoding for biodiversity identification can do by DNA extraction, PCR amplification, DNA sequencing, sequence analysis and comparison, species identification etc.

- **DNA Sequencing**: DNA sequencing involves determining the precise order of nucleotides (A, T, C, G) in a DNA molecule. Various sequencing methods, such as Sanger sequencing or Next-Generation Sequencing (NGS), can be employed. DNA sequencing is used to compare and analyze specific gene regions or whole genomes to identify species and understand genetic variations. Example: DNA sequencing of the mitochondrial COI gene is widely used for DNA barcoding, enabling the identification of species across different taxa, including animals and plants.
- **Polymerase Chain Reaction (PCR):** PCR is a technique used to amplify specific DNA sequences from a small amount of starting material. It allows researchers to target and amplify specific regions of interest for further analysis. Example: PCR amplification of the Internal Transcribed Spacer (ITS) region in fungi helps differentiate closely related species and assists in their identification.
- **Restriction Fragment Length Polymorphism (RFLP):** RFLP is a technique used to detect variations in DNA sequences by using restriction enzymes to cut the DNA at specific sites. The resulting fragment patterns can be analyzed to identify genetic differences between individuals or species. Example: RFLP analysis of the 16S rRNA gene can help differentiate bacterial species based on variations in their DNA digestion patterns.
- **Phylogenetic Analysis:** Phylogenetic analysis involves reconstructing evolutionary relationships among organisms using molecular data. By comparing DNA sequences from different species, researchers can create phylogenetic trees or networks that depict their evolutionary relatedness.

- **Genomic Techniques:** Advanced genomic techniques, such as whole-genome sequencing, can provide comprehensive information about an organism's genetic makeup and aid in species identification, population genetics, and comparative genomics.

These molecular techniques, along with traditional observational and taxonomic approaches, contribute to a comprehensive understanding of biodiversity and aid in conservation efforts, evolutionary studies, and ecological research.

e) Citizen Science Projects:

Citizen Science initiatives, such as iNaturalist or eBird, engage the public in biodiversity identification. Participants upload observations, including photographs or sound recordings, and collaborate with experts to identify species.

f) Expert Assistance:

In complex cases, experts in specific taxonomic groups or local ecosystems may be consulted for accurate identification. These experts possess in-depth knowledge and experience in identifying species within their respective areas of expertise.

g) Collection Specimens:

Collecting specimens for further examination and identification is common in many scientific disciplines. This may involve capturing insects, collecting plant samples, or taking water samples to analyze microorganisms.

h) Remote Sensing:

Remote sensing techniques, such as satellite imagery or aerial surveys, can provide valuable information about biodiversity patterns over large areas. For example, using satellite imagery to identify vegetation types or mapping forest cover to understand the distribution of different tree species.

i) Observational technique

Observational techniques play a vital role in the identification of biodiversity, particularly in the field where direct observations of organisms and their behaviours are made. These techniques rely on keen observation skills and the ability to recognize and document specific features or behaviours of different species. Some common observational techniques used for biodiversity identification are visual observation, behavioural observation, vocalizations and sounds, photography and videography, note-taking and field journals, binoculars and field guides and citizen science platforms etc.

9.3. Measuring Biodiversity

Biodiversity measurement was performed by **Whittaker**. **Species Richness** and **Species Evenness** are the two main factors of measuring biodiversity.

Species Richness:

It denotes the measurement of a number of species diversity in various areas. It is calculated as number of species per located per unit area of a particular community. In simple words, it refers to calculating the species diversity.

It has three components and are as follows:

Alpha diversity:

This indicates number of species in an exclusive community. This diversity comes closest to the popular concept of species richness and can be utilized to differentiate the number of species in distinct ecosystem types.

In more simpler words, diversity in species is referred as Alpha diversity.

Features-

1. Denotes species number enclosed in a group.
2. It relies upon the association between the biotic and abiotic components and considers the migration from other regions.

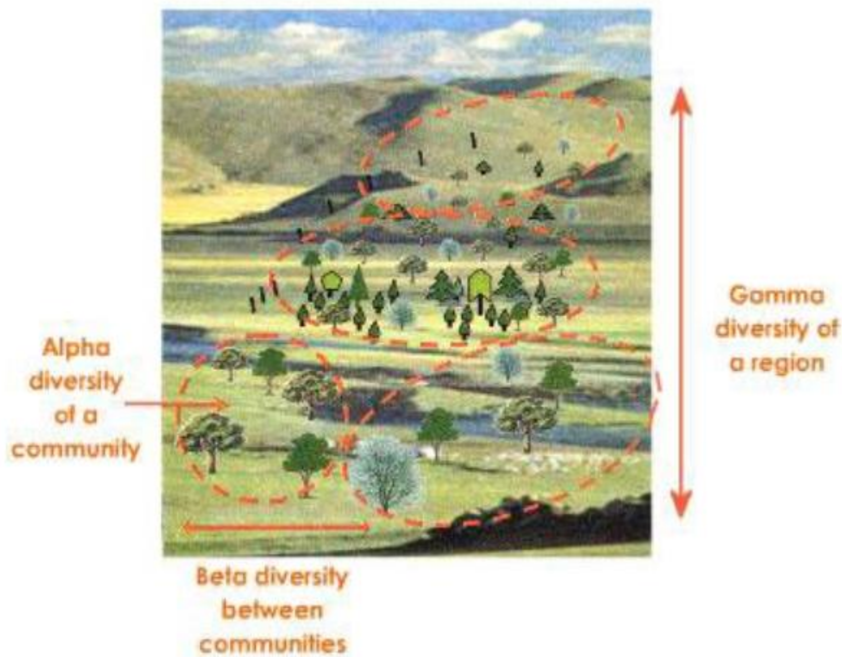
Beta diversity:

This applies to the extent to which species make up changes along an environmental gradient. Beta diversity is high for instance, if the species structure of moss communities' changes at constantly higher altitudes on a mountain slope, but is less if the same community occupying the entire mountain side. In simpler terms, it is the alteration in the species composition in relation to alterations in the environment.

Gamma diversity:

This suggests to the larger geographical scales and defined as “the frequency at which additional species are encountered as geographical replacements enclosed in a habitat type in distinct localities. In simpler terms, this implies to the all-inclusive diversity and is related to the bigger areas in which both alpha and beta diversity are calculated. Therefore, gamma diversity is the species turnover frequency with distance between areas of similar habitat or with growing geographical areas. It is very subjective due to its different understanding regarding the boundaries of that area.

Species evenness: It is the estimation of relative abundance of individuals of distinct species in a specific region. Low evenness often, means that a few species influence/control the region or ecosystem.



Source: Tutorvista

9.4. Biodiversity at Local, National and Global Level

The role of different players in managing biodiversity are-

9.4.1. Local Level:

Basically, governed by communities. Indigenous groups and farmers are two main components.

- **Indigenous groups** - rely on biodiversity for basic survival, for instance- spiritual importance.
- **Farmers** – strong opinion on the conservation as it clashes with their aims

9.4.2. National –managed by government mostly.

- **Regulations**- establish and enforce laws to preserve and save various regions and species. For eg., The Biological Diversity Act 2002.

National biodiversity authority (NBA) was established under The Biological Diversity Act 2002, to accord with requests for using genetic resources by foreigners and to control or monitor the requests to convey the outcome of any related research out of India. If Indians are performing research on genetic resources in India, they are not required to take their (NBA) permission.

- **Preservation-**preservation of biodiversity is often performed through biosphere reserves parks, sanctuaries, protected areas etc.

9.4.3. Global– managed by international treaties.

- **Ramsar convention:** The Ramsar Convention, officially known as the Convention on Wetlands of International Importance, is an international treaty dedicated to the conservation and sustainable use of wetlands. It was adopted in the Iranian city of Ramsar in 1971 and entered into force in 1975. The convention is administered by the Ramsar Secretariat, which is based in Gland, Switzerland. The primary goal of the Ramsar Convention is to promote the conservation and wise use of wetlands. Wetlands are defined in the convention as areas of marshes, peatlands, lakes, rivers, coastal areas, and other water bodies, whether natural or human-made, permanent or temporary, with water that is static or flowing, fresh, brackish, or salt.
- **World heritage convention-** The World Heritage Convention, officially known as the Convention concerning the Protection of the World Cultural and Natural Heritage, is an international treaty adopted by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in 1972. The convention aims to identify, protect, and preserve sites of outstanding cultural and natural significance around the world. It recognizes that certain sites represent the collective heritage of humanity and should be preserved for future generations. The World Heritage Convention has been instrumental in raising global awareness about the importance of cultural and natural heritage and

promoting its preservation. It has led to the recognition and conservation of numerous iconic sites worldwide and fosters international cooperation for their long-term safeguarding.

- **CITES (Convention on International Trade in Endangered Species) -** The Convention on International Trade in Endangered Species of Wild Fauna and Flora, commonly referred to as CITES, is an international treaty established in 1975. CITES aims to regulate and control international trade in endangered species to ensure their survival and prevent their exploitation. The main objective of CITES is to ensure that international trade in wild animal and plant species does not threaten their survival. It seeks to achieve this by regulating and monitoring the international trade of endangered and threatened species and their products. The convention operates through a system of permits and regulations that govern the import, export, and re-export of protected wildlife and plants.
- **World Conservation Union (1948):** ICUN- International Union for Conservation of Nature and Natural resources (ICUN), now called as WCU (World Conservation Union). The union has its headquarters in Gland, Switzerland, and aims to influence, encourage, promote, and assist societies across the globe to preserve the biodiversity of natural resources and their rational utilization.

9.5. Habitat Transformation

Habitat transformation is a change or conversion in land use or land cover which has an influence on local ecosystems. Plants and animals live in particular places that have the surroundings of climate and food resources required for their survival. Habitats range from forest and grassland to urban regions, streams, ponds, lakes, seas, and oceans. Habitat conversion happens when natural habitats are transformed for human applications such as-

✓ Infrastructure development roads, dams, power lines etc.

✓ Expansion as urban regions

✓ Use as Croplands, for instance, 98 percent of the tallgrass prairie and 35 percent of wetlands have become extinct in Nebraska, particularly due to its transformation to cropland.

Scope -

➢ Save the current good-quality wildlife green space.

- Supervise, operate and upgrade deteriorated green space.
- Revive sites of specific importance that have been perished (such as wetlands)
- Advance the accessibility of land usage between sites.
- Generate new forests, lawns, gardens, grasses etc.

9.5.1. Habitat Destruction

The process by which natural habitat is ruined or destroyed to such a degree that it can no longer be able to support the natural occurring species and ecological communities is referred to as Habitat destruction. It often results in the extinction of species and, hence, leads to the loss of biodiversity.

The major cause of biodiversity loss is not direct exploitation done by human but the habitat destruction that inescapably results from the extension of the human populations and their activities. The substantial destruction of biological communities has occurred during the last 150 years with human population surging from 1 billion in 1850, to 2 billion in 1930, to 5.3 billion in 1990, and approx. 6.5 billion by the year 2000. Majority of the vertebrate's facing extinction is due to the threat caused by habitat destruction. Islands of many countries have been populated with high human density, due to which the original habitat has been destroyed. Greater than 50% of the wildlife habitat has been destructed in the old-world tropical nations. 65% of the wildlife habitat has been destroyed, particularly higher frequencies of destruction in Bangladesh (94%), Hong Kong (95%), followed by Sri Lanka (85%), Vietnam (80%) and India (80%).

In general, habitat destruction results in extinction of species, but it can also stimulate or open up new habitat that might produce an environment in which new species can evolve, thus displaying the resiliency of life on Earth. In most cases, the factors lead to destruction of habitat, include-

1- Big industrial and commercial activities related to global economy such as, cattle ranching, mining, forestry, commercial fishing, agriculture, plantation, manufacturing, dam construction with the aim of making profit etc.

2- Forest cut down leads to the huge amounts of habitat destruction each year. Rain forests, tropical dry forests, mangroves, grasslands wetlands, are threatened habitats and are heading towards desertification.

3- Habitat destruction can also happen from natural phenomenon such as- floods, volcanic eruptions, earthquakes, and climate fluctuations.

9.5.2. Habitat Fragmentation

Human growth, progress, success and expansion results in habitat fragmentation, as wild regions are separated and break into smaller fragments. Fragmentation decreases animal orbits and limits their activity, motion and movement, putting the faunas in these locations at greater threat of disappearance and would lead to extinction or loss. Moreover, splitting up the habitat would also result in diminishing genetic diversity, as it separates fauna communities. Environmentalist generally looks after to conserve habitat to protect individual animal community. For instance, Conservation International finances the Critical Ecosystem Partnership Fund (CEPF), an ambition and initiative of many global organizations which furnish funds to the private and non-profitable environmental associations to save the vulnerable habitats across the globe. The associations' goal is to save the "hotspots of biodiversity" which have large concentrations of endangered species, like West African Madagascar and the Guinean Forests. These regions are home to unmatched arrangement of flora and fauna discovered nowhere else around the world. Conservation International considers that protecting these hotspots of biodiversity is the solution to save the earths biodiversity. Habitat destruction is the greatest threat facing wildlife, and it is happening very rapidly at such a frequency that species are starting to vanish in unbelievable figures. Scientists alert that the loss of natural territory (habitat) around the world would lead to more extinction and thus will have serious consequences at social, economic, ecological level, if it does not slow down.

Cheryl-Samantha Owen/Nature Picture Library/Getty Images

Source: Cheryl-Samantha Owen/Nature Picture Library/Getty Images

Fig. 9.1:Pictorial representative of habitat loss, fragmentation, destruction

9.5.3. Over-Exploitation

Rising human population has raised the utilization of natural resources. Harvesting techniques are being greatly manipulated to get extreme benefits. Ancient societies had some measures to avoid the overexploitation in various ways, while in today's world much of the resources are being exploited as quickly as possible. There is also a chance of overexploitation of natural resources when a trading market evolves for an earlier unexploited or regionally used species. Fur trade is the great example in this context. Overexploitation intimidates approximately one-third of the threatened vertebrated around the world in addition to other species. Increasing poverty in rural areas, enhanced tools, processes and techniques for harvesting along with the development of the economy unite to make the most of species to the juncture that species become extinct. Even though the species is not entirely destroyed by over-exploitation the size of the population would become very low and species would not be able to recuperate.

9.5.3.1.Factors affecting over exploitation

There are several components included in overexploitation-

1. Accelerating human population -Increasing human population has intensified the use of unsustainable use of natural resources.
2. Human harvesting- Human harvests several natural resources and organisms as such a rapid rate that it is difficult to be restored and the creatures cannot reproduce it quickly. For instance, examples-the Passenger Pigeon, the fur trade, the fishing industry, Amphibian and reptile industry, the Aurochs etc.,
3. The rich countries over consuming -Several people across the globe think that the developed and wealthy nations are over consuming the biological resources, but the fact is that the poorer nations are putting more burden on
4. Natural resources with their fast-growing population. For instance, African will have an estimated population size of 3 billion, by the centuries' end, which would be 5-fold as compared to the current one. Thus, this increase in the population size will expel the other species territory by means of land for farming, housing, urbanization, infrastructure development.
5. Insufficiency of incentives to conserve such as, environmental taxes-There is a lack of motivation for any nation to restore its act, if there were environmental taxes mandatory across worldwide then countries would be imposed to take attention.
6. Economic growth results in environmental deterioration -It is indicated that environmental deterioration is caused by rise in the economy but reducing the developed nations economic growth leads to the weaken the undeveloped nations. As previously stated, the demand put on the habitat or surroundings will go on enhancing as far as the human community will increase. By 2100, the human population size will be roughly 12 billion and all of us would require a place to live, food to eat, and pure water to drink.

'uman beings are depleting the planet's natural resources.

Source:https://www.iberdrola.com/sustainability/overexploitation-of-natural-resources

9.5.4. Habitat Degradation

Another repercussion of human growing population and expansion is habitat degradation. As the population grows, humans acquire extra land for farm and for building cities and towns out spread over broadening areas. Also, it is indirectly arisen from climate variations, i.e., global warming, introducing alien species, environmental pollution, all of these decreases the environment standard, which makes it difficult for the indigenous flora and fauna to thrive. Some activities or projects may not influence the powerful species in the community, but many other races are affected by such habitat deterioration to a great extent. For instance, physical deterioration of forest domain by unchecked ground fires may not cause huge damage to trees, but the wealthy perennial wild floral or plant community along with the insect fauna on the forest land would be most harmed. Cruising, boating, jumping, etc, in coral reef regions destroy the fragile species (e.g., Maya Bay of Thailand). The most indistinct type of habitat degradation is environmental contamination, which includes pesticide, chemical wastes from industries and factories, automobile and industrial emissions, along with the sediment debris from wrecked hill sides. Environmental damage by pesticides water and air pollutions are already known. Effects of worldwide climate change and acid rains are also very prominent and of worldwide concern.

9.6. Impact of Pollution on Biodiversity

As a consequence of climate change, few coral reef ecological communities of the ocean have reduced. The coastal areas may emerge swiftly because of sudden rise of sea levels, which is predicted to enhance 0.1 to 0.2 meters by the previous century. This is viewed as disastrous to few species. The previous climatic conditions result in diverse species make-up because of distinct abilities of the species to acclimatize to the climatic variations. The preservation of current day biodiversity and ecological equilibrium are the two most important things which is mandatory for the mutual existence of life forms including human. Air pollution is the predominant emergency of the recent decades that has huge deleterious consequence on the climate change and is considered as a big threat to the biodiversity. Impact of acidification, nitrogen fallout, and ground- level ozone where the specific pollutants are sulphur dioxide, compounds of nitrogen and volatile organic substances are the major pollutants. Another serious threat to biodiversity is liberation of greenhouse gasses into the atmosphere. Greenhouse gases resulted in the rise in relocation of tree species towards high elevation. Climate variation and global warming createserious worries today because they influence the natural ecosystem. Climate change indicates the alterations in the universal climate over long term.

Few instances of impact of pollution on biodiversity are-

1. Forest of alpine and boreal are supposed to grow northwards at greater heights and latitudes, and relocate their trees uphill at the region of reduce height tundra and alpine communities. As result of these alterations, numerous plant species (approx. 9%) are at the brink of loss (FAO, 2000).
2. Nevertheless, there are some advantages of air pollution such as- many of the aphid's population are stimulated by the air pollutants, while the species which are resistant to them fill the gap left by the vanishing of the sensitive types.
3. Impact of noise pollution includes- foraging, decline in reproduction, influencing physiology, reduced animal fitness etc.

Source: https://defenders.org/blog/2022/12/pollution-one-of-five-drivers-of-biodiversity-loss

4. Killer whales, or orcas of Pacific Northwest, are the most popular species. They are top predators, and hence valuable for local ecosystems. Native Americans call them as people who live under water. Thus, orcas have a spiritual place, in addition to its cultural and economic importance.

5. The southern ocra inhabitants, established in the Northern Washington State and southern British Columbia waters, was registered as “endangered” in 2005, and now registered as “depleted” under the U.S. Endangered Species Act and Marine Mammal Protection Act respectively. Regardless of this security, the community count is still reduced, just 73 in numbers (as of September 2022).

6. There are several reasons which prevented theses orcas communities from reviving and one of the important problems is pollution, that includes both chemical contaminations and noise pollution.

Source- https://defenders.org/blog/2022/12/pollution-one-of-five-drivers-of-biodiversity-loss

7. Persistent Organic Pollutants or POPs are the most poisonous type of pollutants observed in orcas. Polychlorinated Biphenyls (PCBs), which are used in the submarines; Polybrominated

Diphenyl Ethers (PBDEs) used as flame retardants; Dichlorodiphenyltrichloroethane (DDT) used as an insecticide, dioxins and furans generated as a by-product of burning fossil fuels, wood, plastics are other categories of worst pollutants created across the globe. These pollutants/ chemicals get accumulated

in the fatty layer of the orcas. Greater levels of harmful heavy metals such as mercury and cadmium are also observed in the orca's population.

8. Many other species whose heath is being deteriorated or that are being killed by pollution/ contamination includes-

- Sea turtles and right whales are being captured in the discarded fishing ring.
- Stomachs of fishes and seabirds are full of plastic fragments.
- Frogs are inhaling toxic chemicals from pond water.
- Pesticides destroying bee and insect pollinators.

Keeping in view of the above, there is an urgent demand to decline the flow of pollutants in water, to conserve biodiversity.

9.7. Impact of pesticide on Biodiversity

Application of pesticide has detrimental consequences of biological diversity-

1. Directly exposed body/organisms can induce brief lethal effects.

2. Prolonged outcome can lead from changes to domain or territory/ surroundings and the food chain.

3. These are chemical material or substance invented to be poisonous to the creatures which alter plants growth such as- fungi, insects or weeds.

4. Although, pesticide assist farmers to produce food in more profound and easy way, this creates several external problems such as-they induce death of the other life forms which includes earthworms, bees, mammals, insects etc.

5. Typically, the most harmful, toxic and continuous pollutants delivered into the environment or surroundings have been pesticidesuch as- DDT (dichloro-diphenyl-trichloroethane), dieldrin, agent orange.

6. The lethality and ability to stockpile in the soil and in the food- chain came across after decades of application in agriculture. These pesticides are the major reason behind the deterioration of natural resources, habitat and biodiversity etc., which we face today. Our rigorously used pesticide agricultural framework has been discovered as the greatest reason for the loss of biodiversity. Pesticides can linger for decades in the environment and create an international threat to the whole ecosystem on which food production relies.

7. Extreme application and improper usage of pesticides lead to pollution of nearby soil and water sources, create biodiversity loss, eradicating promising insect populations that act as natural enemies of pests and lowering the nutritional content of food." stated the UN Report of the Special Reporter on the right to food.
8. In the EU, the Plant Protection Regulation (EC) No 1107/2009 acknowledges that pesticides have an important part in ecosystem degradation, we observe today. One of its main aims is to make sure of a top level of security of both human and animal health and ecosystem. This also recommends that pesticide application should have no undesirable effects on the environments and its surroundings [art 2(b, c)].
9. PAN Europe aims to save the pollinators and assured the limited prohibition of neonicotinoids that damage them and restrict the maltreatment of the derogations by the European Union member states.
10. Further, PAN Europe also works towards the pollution of European freshwater systems caused by pesticides, with special attention on the consequences of endocrine-disturbing pesticides on aquatic ecological system.

Source- Pesticides and the loss of biodiversity - Bing images

9.8. Summary

Biodiversity assessment is very alike its monitoring, besides that supervision is performed all over the time to gather data on drifts and swings and possible future orientations of species, communities, or populations in the natural system being analysed. Indeed, an assessment demonstrates the threshold facts from which observance is made. As there are several precautionary warning measures for several natural processes like- earthquakes, catastrophic fires. Tsunamis, hurricanes, and volcanoes has been established, there are no such measures for biodiversity. The major sources of habitat fragmentation are deforestation, overexploitation for fuel wood, overgrazing, agricultural activities and industrialization. Similarly, degradation of soil is done mainly due to overgrazing, farm activities, deforestation, and over exploitation of land to produce fuel-wood, and industrialization. Jam-packed population and various human activities like- urbanisation and road construction are also on the peak, which fragments domains or territories into several parts, as well as enhancing the threat to wildlife-vehicle accident when animals cross the road for food or mating. Different types of pesticides have been applied for crop protection for several generations. They are advantageous to the crop species but they have deleterious consequences on the ecosystem and can also lead to decline in plant and animal biodiversity as it imposes extreme effects on non-target species. Pesticides are also dangerous for the water as well as terrestrial food webs and ecosystems. Uncontrolled application of pesticides has resulted in the decline of several land and fresh water, flora and fauna species. Pesticides which are soluble in water get dissolved and reach ground water, rivers, ponds, lakes, streams, and thereby causing harm to the non-targeted species. Air, water and soil have also been polluted with these chemical substances to poisonous levels. Likewise, pesticides also influence human health as it shows toxic effects when its level increases in the body.

9.9. Terminal questions

Q.1. Define Habitat degradation and habitat fragmentation.

Answer:---

Q.2. What are the various ways of measuring biodiversity?

Answer:--

Q.3. Briefly explain -

a) Habitat Destruction

b) Habitat Transformation

c) Over-exploitation.

Answer:--

Q.4. What are the factors affecting overexploitation?

Answer:--

Q.5. What are the impacts of pesticide on the biodiversity?

Answer:--

Q.6. Discuss the impact of pollution on biodiversity?

Answer:--

9.10. Further suggested readings

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