Bachelor of Commerce
(B.Com)

Environmental Impact Analysis
(DBCMAE201T24)

Self-Learning Material
(SEM II)

Jaipur National University
Centre for Distance and Online Education

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Table of Contents

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Course Introduction

Environmental Impact Analysis is assigned 2 credits and 6 units. Environmental studies emerged as a distinct field of study in the mid-20th century, because of the growing awareness and concern about the environmental impacts and challenges of human activities, such as industrialization, urbanization, population growth, and consumption.

The scope of environmental studies in India is vast and diverse, encompassing a wide range of fields and disciplines. Environmental studies in India focus on understanding the complex relationships between human and natural systems, and addressing the various environmental challenges facing the country, such as climate change, deforestation, air and water pollution, and biodiversity loss. The field includes research and analysis of environmental policies and regulations, environmental impact assessments, sustainable development practices, and conservation efforts. Furthermore, environmental studies in India aim to raise public awareness and education about environmental issues, and to develop innovative solutions to ensure a sustainable future for the country.

Each unit is divided into sections and sub-sections. Each unit begins with statement of objectives to indicate what we expect you to achieve through the unit.

Course Outcomes

After studying this course, a student will be able to –

1. Recall the basics of Environmental Management, its concepts and principles
2. Review the Energy sector and its management in current scenario.
3. Determine the environmental issues, ethics and management system.
4. Analyze the environment needs, problems and develop sustainable development
5. Assess the environmental protection laws and review the UN Convention on Biodiversity.
6. Develop a desired course of action for optimal utilization of scarce environmental resources within legal framework.

We hope you will enjoy the course.

Acknowledgement

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Unit: 1

Ecosystem

Learning Objectives:

- Understand the Ecosystem
- Learn about its Structure & Functions
- Get known important terms
- Understand their meanings with examples

Structure:

1.1 Ecosystem: An Introduction

An ecosystem is a structural and functional unit in ecology where organisms interact with their immediate surroundings and with one other. Put another way, it may be described as a sequence of interactions that take place between the organism and its environment. The term "ecosystem" was originally used and developed in 1935 by the English botanist A.G. Tansley.

Ecosystem research focuses on the interactions between coexisting species and the transfer of energy among the creatures in an ecosystem. In order for an organism to survive sustainably, it also takes into account how it interacts with other living things, whether positively or negatively. Nature serves as an example of how the amount of abiotic materials in an ecosystem's surroundings can affect that ecosystem's growth. The ecosystems in the north and south poles are not as rich in flora and fauna as those in tropical regions, such as forests, because of their harsh conditions. As a result, the ecosystem can only benefit from organisms that can thrive in such conditions. Several interdependent ecosystems make up a biosphere.

A significant example of an ecosystem is a pond. Ecosystems can be found in ponds, lakes, deserts, grasslands, meadows, forests, etc.

1.1.1 Two Components of the Ecosystem

- Biotic Components
- Abiotic Components

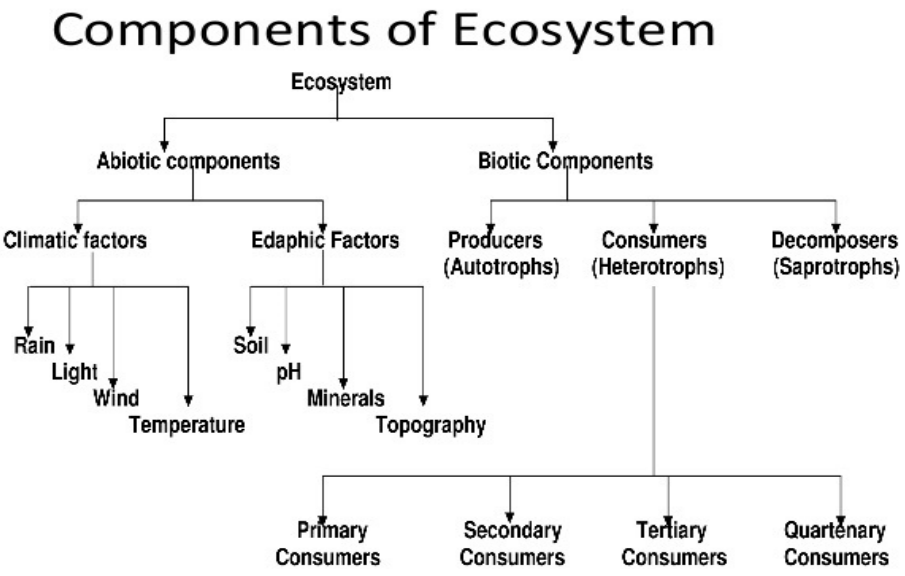

Figure 1.1: Components of the Ecosystem

Source: EDUINDEX NEWS

- **Abiotic factors** are nonliving elements of the environment that impact how living things interact. They consist of the following:
  Physical Environment: The ecosystem's surrounding conditions, including soil type, topographical characteristics, water availability, temperature, humidity, and sunlight.

- **Biotic elements** are the ecosystem's living creatures. They can be divided further into three major categories:

- **Producers:** Through photosynthesis, plants, algae, and some microorganisms can create their food.

- **Consumers**: Animals and other species that get energy from eating other organisms are considered consumers. These are further classified into the following categories:
  - First Eaters: These animals consume food directly from the growers. Similar to giraffes, deer, rabbits, cows, and buffalo, they are herbivorous animals.
  - Secondary Eaters: These animals rely on the primary consumers for their nourishment. These animals include both carnivorous and omnivorous species, such as crows, dogs, cats, and snakes.
  - Tertiary Eaters: These animals ingest secondary consumers, sometimes known as tertiary consumers. These are the only animals that are strictly carnivores—they only consume flesh and usually hunt larger animals like lions, tigers, or cheetahs.
  - Quaternary Eaters: Tertiary consumers provide the food for these organisms. An eagle, for example, might eat a snake, which would eat a frog, which would eat a fly.

- Decomposer: Microorganisms such as fungi and bacteria that break down organic materials and release nutrients back into the environment..

Figure 1.1 demonstrates the interconnectivity of these elements within an ecosystem. The energy from the sun is transformed or converted into food by producers, which consumers eat subsequently. Decomposers disintegrate the remains of deceased creatures, supplying the

ecology with nutrients. All living things can access the materials and factors they need from their physical surroundings.

Understanding that different habitat types, such as forests, grasslands, oceans, or deserts, might have very different ecosystems is essential. Although each ecosystem has its specific mix of parts and interactions, the above flowchart captures the essential elements common to most ecosystems.

1.2 Structure & Functions of Ecosystem

The ecology fulfills the subsequent functions:

- It preserves equilibrium, upholds biological systems, and regulates essential ecological functions.
- It also controls the transport of nutrients between biotic and abiotic components.
- It maintains the equilibrium between the different trophic levels within the ecosystem.
- The ecosystem as a whole receives circulation of the minerals.
- The abiotic components aid in the synthesis of organic components, which entails the exchange of energy.
- As a result, the following are the functional components or units of the ecosystem:
    - Productivity: Productivity is the rate of biomass production.
    - Energy flow: The process by which energy shifts systematically from one trophic level to the next is known as "energy flow." The energy from the sun travels through solar energy generators, consumers, decomposers, and finally returns to the environment.
    - Decomposition is the natural breakdown process of dead biological substances. The majority of degradation happens in the topsoil.
    - Nutrient cycling: IIn an ecosystem, nutrients are utilized by one creature and subsequently recycled in different ways for use by another. This process is known as nutrient cycling.

To help you comprehend, these functions are further explained.

- Productivity:

The gross primary productivity (GPP) of an ecosystem quantifies the rate at which organic matter is generated by photosynthesis.In order for plants to respire, GPP is essential. Gross primary productivity less respiration losses (R) yields net primary productivity (NPP).

GPP - R = NPP is the biomass that is available for consumption by heterotrophs, which include herbivores and decomposers. Furthermore, the pace at which consumers produce new organic matter is known as secondary productivity.

- Energy Flow

Because they connect an ecosystem's biotic and abiotic components, food chains and energy flow are two characteristics that give ecosystems their dynamic nature. With the exception of the marine hydrothermal ecology, all ecosystems on Earth rely solely on the Sun for their energy, and less than half of incident solar radiation is made up of PAR (photosynthetically active radiation). Plants only absorb between 2 and 10% of PAR, yet even so, this tiny amount of energy is sufficient to support all life on Earth.

Farmers provide food for all species, either directly or indirectly. As a result, energy moves alone from the sun through producers and onto consumers.

Ecosystems need a steady supply of energy in order to synthesize the molecules necessary to counteract the overall tendency toward increasing disorderliness.

Energy flows in an ecosystem in a linear or one-way fashion.

As time passes, less energy flows through the different trophic levels, as seen by the size of the boxes in Figure 1.2. In a food chain or web, every organism uses the energy it gets at that particular moment to sustain itself.

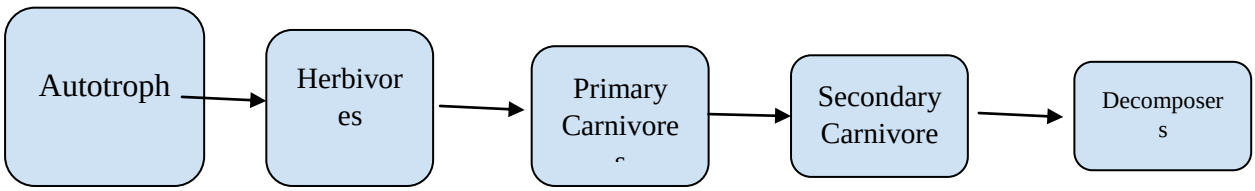

Figure 1.2: Energy Flow in an Ecosystem

1.3 Food Chain

The ongoing process of eating and being eaten by various species through a chain of producers (green plants) is called a food chain.

1.3.1 Types of food chains:

- **Grazing Food Chain:** It begins with green plants that produce food for herbivores, providing food for predators. Only 10% of the energy is transferred from the lower trophic level to each trophic level in the grazing food chain, which is governed by a 10% law.
- **Detritus Food Chain:** It begins with decaying biological materials. For protozoans, carnivores, and other species, detritivorous organisms produce food.

The energy source for the first-level customers is a significant point of difference between these two food chains.
Living plant biomass is the primary energy source in the grazing food chain, whereas detritus, or dead organic matter, is the primary energy source in the detritus food chain.
The two chains work together to form a y-shaped food chain in an ecosystem.

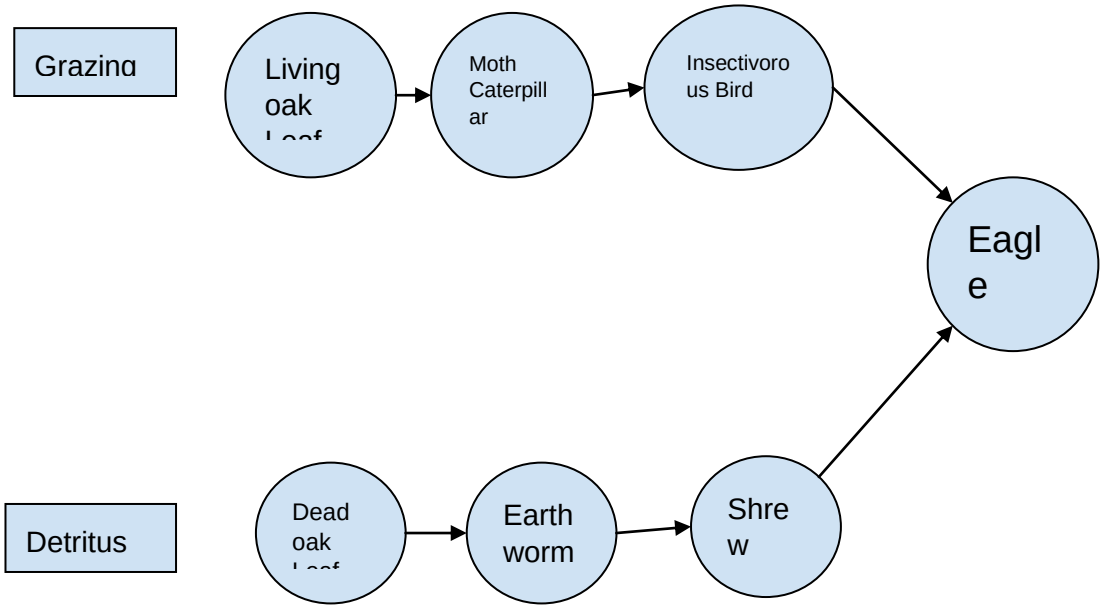

Figure 1.3: Y-shaped Food Chain

Another example of a food chain is mentioned below.

The grasshopper eats the plant, which is eaten by a mouse. The snake then eats a mouse, followed by an eagle. When the eagle dies, its body is broken down into nutrients by fungi. W of sun and water, these nutrients lead to grass growth.

1.4 Food Web

Charles Elton first proposed the concept of the "food cycle," sometimes known as the food web, in 1927. A food web, according to Charles Elton, consists of: herbivores, which consume plants that receive energy from the sun, and predator species, which hunt them down. Other carnivores may also prey on the latter group of predators.
There are food chains among animals, and at the end of the day, they are all dependent on plants. This is called a food chain, and the collective term for all the food chains within a community is the food web. An animal develops a terminal on this food cycle until it reaches a point where it has no enemies.

A food web represents relationships between species that make up an ecological community. A particular ecosystem's food chains are included in the food web. They serve as an example of numerous methods of feeding. The food web explains the energy transfer through species in a community.

Within an ecosystem or natural setting, there exist interrelationships among the food chains. Because an organism might be a part of more than one food chain, these linkages can be highly complex. A food web is made up of all the food chains that are connected to one another and overlap within an ecosystem.

Every living thing is accountable and is a member of various food chains in the specific ecosystem. Food webs are an integral component of an ecosystem; they allow an organism to get food from multiple kinds of creatures of the lower trophic level.

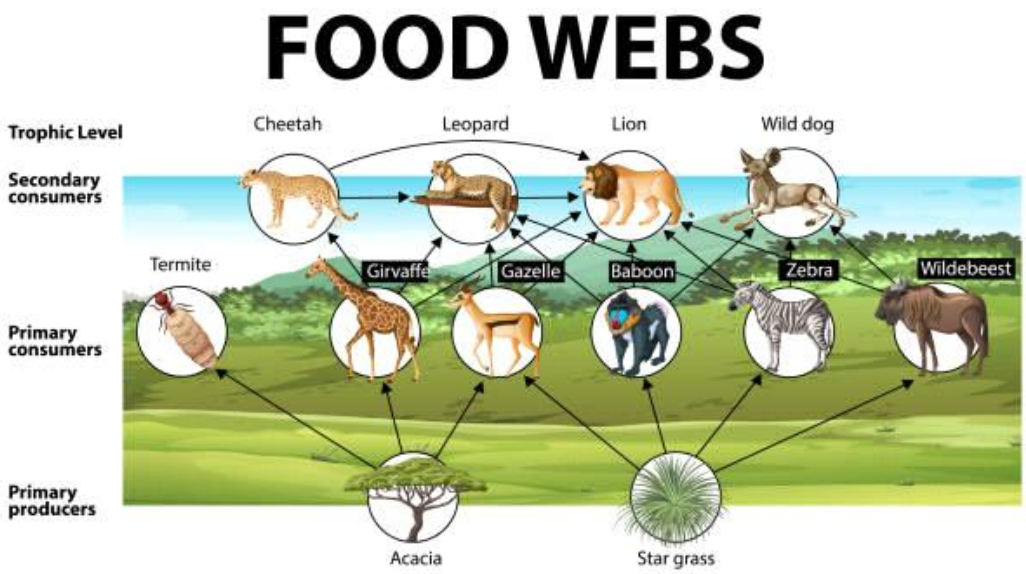

Figure 1.4: Food Web
Source: iStock

1.5 Ecological Pyramid

The ecological pyramid illustrates various creatures' trophic levels based on their roles as producers and consumers. Using an ecological pyramid, the biomass or bio-productivity at each trophic level is graphically represented.

Each horizontal bar in the pyramid represents a different trophic level; the length of a bar indicates the total number of individuals, biomass, or energy at that level in an ecosystem. At the base and apex of the pyramid is the food producer. In between are other consumer trophic levels.

Biomass pyramids illustrate the amount of biomass and its distribution among species at each trophic level. The biomass output or turnover is displayed by the productivity pyramids. Ecological pyramids start at the base with producers, such green plants, and move up through the trophic levels to include herbivores that consume plants, predators that consume herbivores, carnivores that consume other carnivores, and so forth.

The highest level is displayed at the top of the chain.. Energy will predictably move through the food chain, entering the base through primary producers' photosynthesis before rising to higher trophic levels.

The quantity of energy entering each trophic level should impact the abundance and biomass of organisms there. Pyramids of biomass and numbers will emerge when there is a direct association between energy, numbers, and biomass.

1.5.1 Types of Pyramids

- **Pyramid of Numbers**

The total number of people from various species present at each trophic level, also known as the population of the tropical group, is represented by a pyramid of numbers which can be either upright or fully inverted.

The pyramid of numbers only partially defines the trophic structure of an ecosystem because it is challenging to enumerate all the creatures present there. For example, the ecosystem of grassland is upright because the population decreases from a lower level to a higher level. However, the ecosystem of a tree is inverted because the population at each trophic level increases from lower to higher levels.

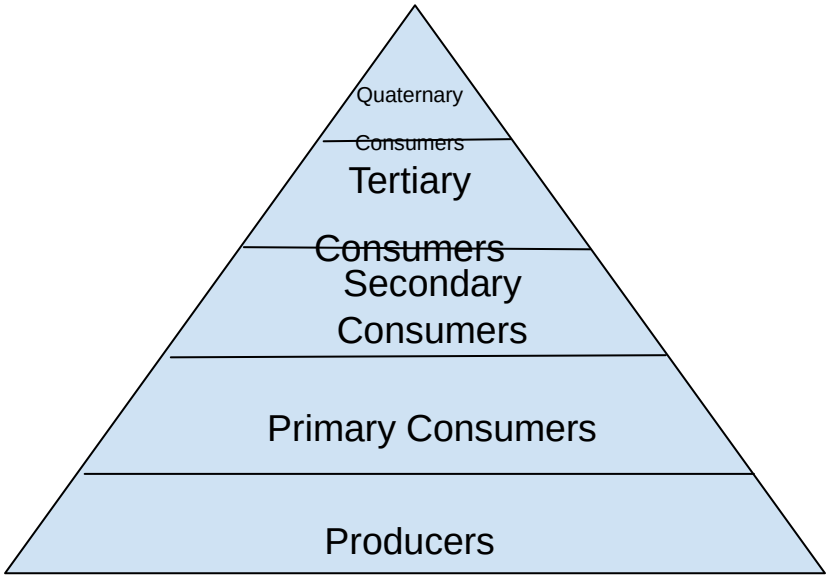

Figure 1.5: Pyramid of Numbers in Grassland Ecosystem

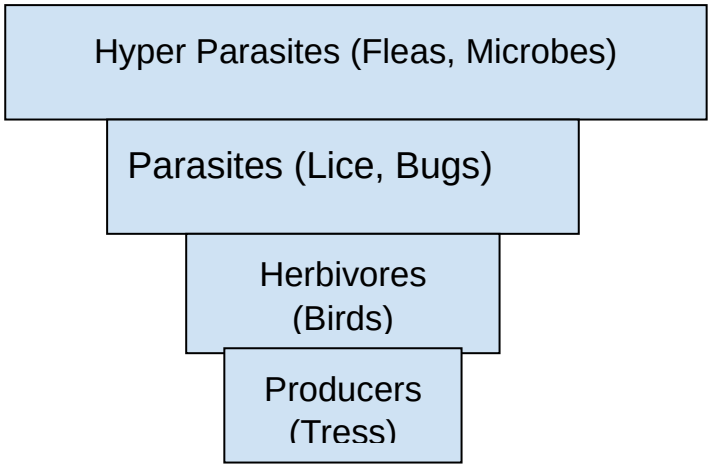

Figure 1.6: Pyramid of Numbers in Tree Ecosystem

- **Pyramid of Biomass**

The biomass pyramid represents the dry weight of all creatures. Typically, it is calculated by gathering every organism in each trophic level separately and weighing their dry weight. The unit for measurement of biomass is g/m2. Because primary producers dominate the base of the biomass pyramid on land and a lower trophic level is present at the top, the biomass pyramid is always upright.

The biomass pyramid is present in many aquatic ecosystems in an inverted form. This is because the producers are tiny phytoplankton that quickly develop and reproduce.

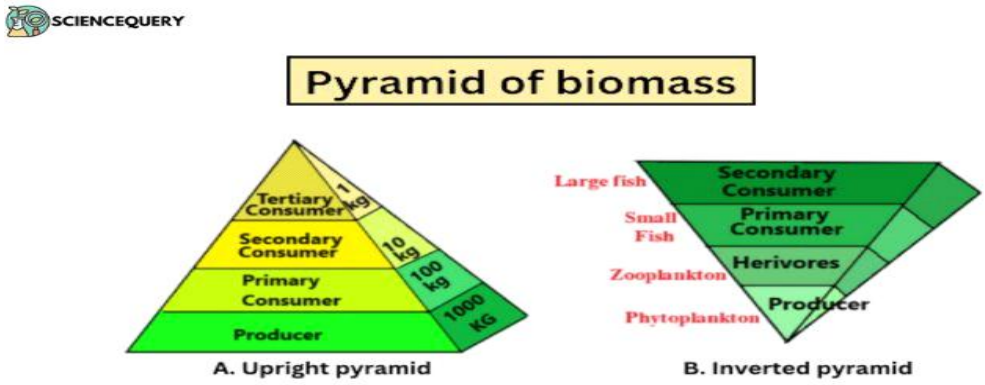

Figure 1.7: Pyramids of Biomass

Source: Science Query

- **Pyramid of Energy**
-

The energy pyramid represents the movement of energy from lower trophic levels to higher trophic levels. During the transfer of power from one creature to another, there is a notable energy loss that takes the form of heat. The primary producers, such as autotrophs, have more energy easily accessible, whereas tertiary consumers have the least. As a result, shorter food chains have more energy availability even at the highest trophic levels.

The amount of energy at each trophic level and the point lost during the transfer to a different trophic level is represented by an energy pyramid.

As a result, the pyramid is always upward and has substantial energy at its base.

1.6 Biogeochemical Cycle

The words ``bio" and "geo" refer to the biosphere, "geochemical" refers to the elements that circulate through a cycle, and "chemical" refers to the geological components. The earth's energy from the sun is radiated back as heat while some substances remain in a closed system. These elements include Carbon, Nitrogen, Hydrogen, Oxygen, Phosphorus, and Sulphur. These, therefore, are recycled by the components of the ecosystem. These cycles offer an illustration of the use of energy. They move the elements about the biosphere that are necessary for life to exist. They are necessary because they physically handle, store, and recycle critical resources. These cycles demonstrate the interactions between living and nonliving entities in ecosystems, which allows ecosystems to persist.

1.6.1 Types of Biogeochemical Cycles

1. Water Cycle

The water from the different bodies condenses, cools, and evaporates before raindrops fall back to the earth.
The weather is maintained via a cycle of biogeochemical reactions. Water interacts with the environment, changing the pressure and temperature of the atmosphere in all its manifestations.

Another mechanism that aids in this process is evapotranspiration, or the vapour that leaves produce. Rain is formed when water that evaporates from leaves, soil, and water sources and enters the atmosphere condenses.

2. Carbon Cycle

The carbon cycle involves the exchange of carbon between the biosphere, geosphere, hydrosphere, atmosphere, and pedosphere. In green plants, photosynthesis is the result of the combination of carbon dioxide and sunshine. The plant stores carbon as a result. The green plants are buried in the earth after they die, releasing carbon to produce fossil fuels. When these fossil fuels are consumed, carbon dioxide is released into the atmosphere.

Furthermore, plants store carbon, which is obtained by animals that consume them. The carbon in these creatures is returned to the atmosphere during their decomposition after death. Animal respiration releases carbon into the atmosphere through cell respiration. Furthermore, enormous amounts of carbon dioxide are produced, stored as fossil fuels (coal and oil), and recovered for a variety of non-commercial and commercial applications. When these fuels are burned in factories, carbon is released into the atmosphere once more.

3. Nitrogen Cycle

Through this biogeochemical cycle, nitrogen is transformed into a variety of forms and moves through the atmosphere and many habitats, including terrestrial and marine ecosystems. Bacteria in plant roots convert this nitrogen gas into the useful chemical ammonia. Plants are also fertilized using ammonia-containing fertilizers. This ammonia produces nitrites and nitrates. Denitrifying bacteria transform nitrates into nitrogen, which is then discharged into the atmosphere.

4. Oxygen Cycle

The lithosphere, the biosphere, and the atmosphere are all involved in this biogeochemical cycle. About 21% of the earth's atmosphere contains oxygen in its elemental form. During photosynthesis, plants emit oxygen. When people and other animals breathe in oxygen, they

exhale carbon dioxide, which plants absorb. They use this carbon dioxide during photosynthesis to turn it into oxygen, continuing the cycle.

5. Phosphorus Cycle

Phosphorus travels through the hydrosphere, lithosphere, and biosphere throughout this biogeochemical cycle. The weathering of rocks releases phosphorus. Phosphorus is removed from the soil and water bodies by rain and erosion. To grow and thrive, animals and plants acquire this phosphorus from the soil and water. It is also necessary for the growth of microorganisms. When plants and animals perish, they decompose, returning the stored phosphorus to the soil and water bodies, where it is once more absorbed by new plants and animals, continuing the cycle.

- Sulphur Cycle

This biogeochemical cycle passes through living things, water, and rocks. When rock weather, sulphur gets released into the atmosphere and changed into sulphates. The bacteria and plants absorb these sulphates and transform them into organic forms. Animals take in organic sulphur through their diet. The cycle is continued when an animal decomposes, returning sulphur to the soil where plants and bacteria once more consume it.

1.7 Summary

- A.G. Tansley, an English botanist, first coined and used the word "Ecosystem" in 1935.
- Abiotic factors are non-living components of the environment that impact how living things interact.
- Biotic elements are the ecosystem's living creatures.
- The rate at which biomass is produced is known as productivity.
- Energy flow refers to the systematic transfer of energy between different trophic levels.
- The process by which decomposing organic matter is broken down is called decomposition. The majority of degradation happens in the topsoil.
- •Nutrients are consumed by one organism in an ecosystem and then recycled in a variety of ways for use by other organisms.

- Living plant biomass is the primary energy source in the grazing food chain, whereas detritus, or dead organic matter, is the primary energy source in the detritus food chain.
- In 1927, Charles Elton introduced the idea of the food web, which he called the "food cycle."
- A food web visually represents the relationships between the species that comprise an ecological community.
- A food web is made up of all the food chains that overlap and are connected within an ecosystem.
- The trophic levels of different organisms are depicted by the ecological pyramid according to their roles as producers and consumers. Using an ecological pyramid, the biomass or bio-productivity at each trophic level is graphically represented.

1.8 Keywords

- **Ecosystem:** It is a structural and functional unit where living things interact with one another and their surroundings.
- **Abiotic factors:** These are non-living components of the environment that impact how living things interact.
- **Biotic elements:** These are the ecosystem's living creatures.
- **Energy flow**: It is the method by which energy moves systematically from one trophic level to another.
- **Nutrient cycling:** In an ecosystem, nutrients are used by one organism and then recycled in various ways for utilisation by another.
- **Food chain:** The ongoing process of eating and being eaten by various species through a chain of producers (green plants) is called a food chain.

1.9 Self-Assessment Questions

1. What does the study of ecosystems primarily focus on?
2. Define abiotic factors in the context of an ecosystem.
3. Describe the process of energy flow in an ecosystem, highlighting its importance.
4. Write a short note on the biogeochemical cycles.
5. Explain the concept of productivity in an ecosystem and its significance.

6. Discuss Charles Elton's contribution to the field of ecology, particularly concerning the concept of the food web.
7. Explain the interconnected nature of food chains within an ecosystem and how they collectively form a food web.
8. Elaborate on the ecological pyramid and how it represents the trophic levels and biomass of organisms in an ecosystem.
9. Compare and contrast the grazing and detritus food chain regarding their primary energy sources and the organisms involved.
10. Who is credited with coining and using the term "Ecosystem" for the first time?

1.10 Case Study

In a forest ecosystem, introducing an invasive species has disrupted the food chain. The dynamics of the food web can be changed by invasive species, which can significantly impact native species and cause ecological imbalances.

Questions:

Based on your understanding of this situation, answer the given questions.

1. What are the invasive species in the forest ecosystem, and what are their characteristics and ecological traits?
2. What are the direct and indirect impacts of the invasive species on different trophic levels in the forest food web?
3. How do human activities contribute to the spread of invasive species, and what are the implications for ecosystem management and conservation?

1.11 References

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Unit: 2

Biodiversity

Learning Objectives:

- Know the concept of Biodiversity
- Understand the causes of its depletion
- Become aware
- Learn ways to conserve

Structure:

2.1 Biodiversity and its Values

Biodiversity is the term used to describe all life on Earth. Every single type of life on Earth is included in the biodiversity, ranging from the largest whale to the smallest microbe on land. Relationships between these lifeforms and their habitat are component of biodiversity as well.

Principles

Different species or groups of autonomously reproducing organisms are commonly referred to as "biodiversity". Marine life, white-tail deer, pine forests, fresh flowers, and miniscule bacteria that are invisible to the human eye are just a few of the species that call Earth home.

Basic biodiversity values can be divided into the following groups:

- Environmental Principles: By examining the functioning of the ecosystem, it is possible to assess the environmental benefits of biodiversity. Intensive agricultural production ecosystems, for example, provide ecosystem services that support human needs and activities. These include creating and preserving healthy soil, conserving clean groundwater supplies through vegetation, and producing oxygen by plants and microalgae on or beneath the surface.
- Economic Values: Biodiversity has a significant economic impact on food, animal feed, healthcare, morals, and social values. An invaluable resource for many of the industries that drive the world economy is the biosphere.
- Consumption-related values: The naturally occurring goods utilised for food, including feed for cattle, wood products, fuelwood, and other things, are consumed daily. Humans, as per research, consume around 40,000 plant and animal species daily. Many people continue to rely on wildlife for their needs, including food, a temporary place to stay, and clothing.
- Productive use values suggest that the goods are sourced and professionally advertised. The crops that we see today are an evolved form of wild varieties. Biotechnologists constantly work with wild plant species to develop new, more productive, disease-resistant plant varieties.

- Aesthetic values: In addition to enhancing life quality, biological diversity is a major factor in some of nature's most breathtaking aspects. Biodiversity contributes significantly to the terrain's beauty.

2.2 Types and Levels of Biodiversity

Biological diversity broadly describes the transition of life from genes to ecosystems. It includes their existence, genetic variations, environments, populations, and the ecosystems in which they are present, as well as other evolutionary advancements that keep the system functioning, changing, and adapting.

Depending on the degree of variations, biodiversity is divided into many components.

- Genetic Diversity: It is the diversity of every species. No two members of the same species are alike. Humans, for instance, exhibit a great deal of biodiversity. There are significant distinctions between inhabitants of different places. Genetic diversity is necessary for a population to adjust to shifting environmental conditions.
- Species Diversity: It denotes the variety and abundance of species. A region's species density fluctuates greatly depending on its environmental conditions. For instance, it is frequently seen that a human culture near water sources exhibits more species than elsewhere.
- Ecological Diversity: It is the diversity present among an area's ecosystems. Numerous environmental ecosystems, including mangroves, deserts, and rainforests, exhibit a great diversity of living forms inhabiting there.

2.3 Depletion of Biodiversity

The term “Biodiversity loss” refers to the depletion of biodiversity and its elements due to various reasons and mainly human activities.

Year	Population	Land area converted for human use	Loss of species in ecosystems
1800	0.9 billion	7.6 %	-1.8 %
1900	1.7 billion	16.9 %	-4.9 %
2000	6.1 billion	39.3 %	-13.6 %
2100 *Green model*	8.7 billion	33.4 %	-11.6 %
2100 *Current model*	12 billion	49.1 %	-17 %

Figure 2.1: Loss of Biodiversity

Source: IBERDROLA

The five primary causes of biodiversity loss are overexploitation, pollution, invasive species, habitat loss, and climate change brought on by global warming. Every scenario involves direct human involvement and action.

- Habitat Loss: The term refers to the reduction, dispersion, or total eradication of an ecosystem's soil, plant, hydrologic, and nutrient resources.
- Species that are not native to a region: An invasive species is any non-native species that modifies or disrupts the ecosystems in which it establishes a major presence. Invasive species have the capacity to upset ecosystems because they present more competition than native species. They might exploit food sources more efficiently or swiftly, or they might occupy areas before local species have a chance to adapt to the altered environment. Certain alien species prey on indigenous species, which may be soon wiped off if the original species lack natural defences against the invaders.
- Overexploitation: The practice of taking too many aquatic or terrestrial animals, commonly referred to as overhunting and overfishing, results in the depletion of certain species' populations and the extinction of other species. It also shows that

consumption happens more quickly than natural regeneration, which has an impact on the planet's flora and fauna.

- Pollution: Pollution is the addition of unwelcome or harmful substances or nutrients to the environment. In a polluted environment, the quality of food, water, and other habitat resources declines, perhaps to the point that specific species are compelled to leave or go extinct if the pressure is too great.
- Climate Change: The average air temperature on Earth has been gradually rising over the past century or two due mostly to human activities, a phenomenon known as global warming. It might specifically be referring to heat brought on by rising atmospheric concentrations of greenhouse gases like methane and carbon dioxide. The natural cycle of breeding and resource availability is upset when predicted temperature and rainfall patterns are changed because more heat is accessible. Ecosystems that rely on the ice for their survival also diminish when it melts and crumbles.
- Population: The tropical regions, which comprise only approximately one-fourth of the world's total surface, are home to nearly three-fourths of the world's inhabitants. Half of all species on Earth are found in tropical rainforestsTherefore, the overpopulation is one of the factors causing the loss of biodiversity, which has led to extensive resource exploitation and deforestation.
- Other factors: Earth's flora and animals suffer harm from natural disasters such as forest fires, droughts, floods, volcanic eruptions, earthquakes, etc. Pesticides and other contaminants, such as harmful heavy metals and hydrocarbons, wipe out the weak and delicate species.

Figure 2.2 states some more reasons that lead to the overall depletion of biodiversity.

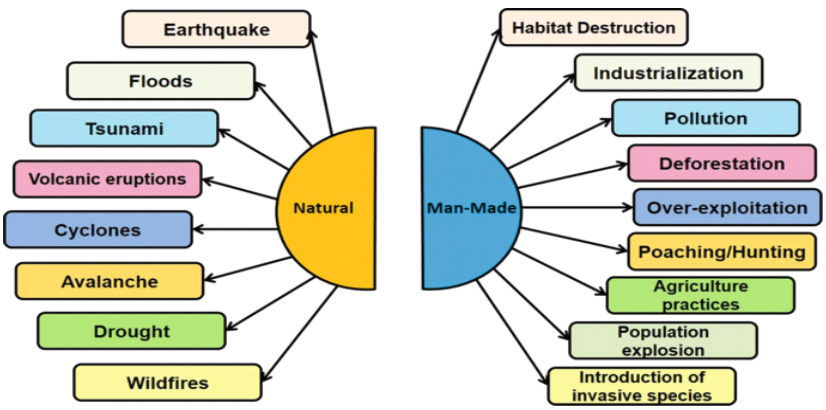

Figure 2.2: Causes of Depletion of Biodiversity
Source: Springer Link

The well-being of the human race will suffer due to biodiversity loss. It will increase the number of animals that spread disease among the local inhabitants. Studies have revealed that the most active infection vectors are also the species best adapted to survive in highly fragmented habitats.

2.4 Conservation

It is necessary to preserve and maintain biodiversity in order to obtain resources for sustainable development. An ecosystem is more likely to be stable in a location with a higher species abundance than one with a lower one. We are directly dependent on different plant species to meet our varying needs. It is for this reason that we must protect biodiversity.

- The preservation of species diversity is one of the fundamental objectives of biodiversity protection.
- Use ecosystems and species sustainably. Preserve the essential ecological processes and systems that sustain life.

2.4.1 Methods of Biodiversity Conservation

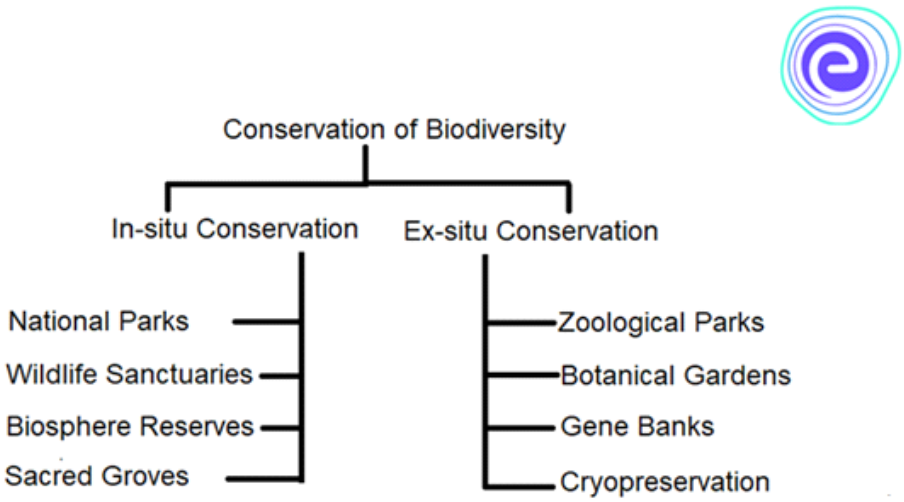

Figure 2.3: Conservation of Biodiversity: Methods

Source: EMBIBE

1. In-situ Conservation

In-situ conservation of biodiversity refers to the preservation of species in their natural habitat. With this method, the natural ecology is protected and maintained. Biosphere reserves, national parks, and wildlife sanctuaries are a few examples of protected areas where in-situ conservation is executed.

There are numerous advantages to in-situ conservation. Among the many important advantages of in-situ conservation are the following:

* It is a cost-effective and useful method for protecting biodiversity, allowing for the simultaneous preservation of a wide variety of living organisms.

* In a natural ecosystem, the organisms are better able to adapt to different environmental conditions and evolve more successfully.

- National parks

  To preserve species, the government manages, creates, and protects National Parks, which are small. All human activity is prohibited in these parks. Kanha National Park and Bandipur National Park are two examples.

- Wildlife Sanctuaries

  These are the only places on earth where wild animals can be found. Human activities like logging, farming, gathering wood and other forest products are permitted here as long as they don't get in the way of the conservation initiative. Additionally, tourists travel to these locations for recreation and awareness.

- Biosphere Reserves

  Residents create and maintain biosphere reserves for the sustainable growth and protection of wildlife, flora, and the ecosystem. It comprises both terrestrial and aquatic ecologies. Activities like tourism and research are allowed within these reserves.

- Sacred Groves

  The entire forest's trees and creatures are revered and granted complete protection by a deity in sacred groves, a specific forest region. They aid in preserving the biodiversity of our nation. No one can harm any living thing in these holy groves since they are self-sustaining mini-ecosystems containing plants and animals.

2. Ex-Situ Conservation

Breeding and maintaining endangered species in artificial habitats like zoos, nurseries, botanical gardens, gene banks, etc., is known as ex-situ biodiversity conservation. Fewer organisms are competing with one another for food, water, and available space.

The benefits of ex-situ conservation are as follows:

- The animals are given more time and opportunities for reproducing.
- It is possible to reintroduce the captive-bred species to the wild.
- It is possible to apply genetic approaches to protect threatened species.

- Zoological Parks
-

  Animals are relocated from their natural habitat to zoological parks for protection and reproduction. The general public is welcome to go there and witness these animals.

- Botanical Gardens

  A variety of living plant species are preserved here. It resembles a demonstration garden with a variety of plants. They aid in advocating, researching, and preserving threatened plant species.

- Gene Banks

  These are organizations that maintain stocks of frozen germplasm with a broad range of genetic variety, living plants (orchards), healthy seeds (seed banks), and tissue culture.

2.4.2 Other Strategies of Conservation

- Livestock, agricultural animals, wood plants, and agricultural food products should all be preserved.
- Animals that have economic value ought to be protected.
- Animals should have access to other habitats.
- The overuse of natural resources needs to be avoided.
- Hunting and poaching of wild animals ought to be prohibited.
- It is necessary to create natural reserves and protected places.
- More trees should be planted, and deforestation should be stopped.
- Strict legislation should be put into place and adhered to.
- Alternative strategies for pollution control should be developed.
- It is essential to raise public awareness of the need to protect biodiversity.
- Preservation of threatened species in both their natural and artificial habitats should be done to prevent their extinction.

2.5 Summary

- The biodiversity of Earth includes every single individual life form, from the tiniest bacteria on the Earth's land to the gigantic whale in the sea.
- The term "biodiversity" is frequently used to refer to distinct species or groups of independently reproducing living things.
- Biological diversity broadly describes the transition of life from genes to ecosystems. It includes their existence, genetic variations, environments, populations, and the ecosystems in which they are present, as well as other evolutionary advancements that keep the system functioning, changing, and adapting.
- Genetic diversity is necessary for a population to adjust to shifting environmental conditions.
- A region's species density fluctuates greatly depending on its environmental conditions.
- For our diverse needs, we rely directly on various plant species. Similar to how we rely on different animal and microbial species for varied reasons. Therefore, we need to conserve biodiversity.

- The preservation of species in their natural habitat is considered in-situ biodiversity conservation.
- Breeding and maintaining endangered species in artificial habitats like zoos, nurseries, botanical gardens, gene banks, etc., is known as ex-situ biodiversity conservation.

2.6 Keywords

- **Biodiversity:** The term "biodiversity" is frequently used to refer to distinct species or groups of independently reproducing living things.
- **Genetic Diversity:** It is the diversity that every species member expresses genetically. No two members of the same species are exactly alike.
- **Species Diversity:** It denotes the variety and abundance of species. A region's species density fluctuates greatly depending on its environmental conditions.
- **Ecological Diversity:** It is the diversity present among an area's ecosystems. Numerous environmental ecosystems, including mangroves, deserts, and rainforests, exhibit a great diversity of living forms inhabiting there.
- **Habitat Loss:** The thinning, fragmentation, or complete elimination of an ecosystem's plant, soil, hydrologic, and nutrient resources is known as habitat loss.

2.7 Self-Assessment Questions

1. What is the difference between in-situ and ex-situ conservation of biodiversity?
2. Why is genetic diversity necessary for populations?
3. Explain in detail two examples of in-situ conservation of Biodiversity.
4. As an aware student, what ways would you suggest to conserve the depleting biodiversity?
5. Mention five causes of Biodiversity Loss.
6. Why is it important to conserve biodiversity?
7. How do humans rely on different plant, animal, and microbial species, and why is it crucial to conserve biodiversity to meet our diverse needs?
8. Genetic diversity is necessary for a population to adjust to shifting environmental conditions. Comment.
9. Are Zoological and National parks the same? Explain their role in the conservation of biodiversity with some examples.

10. Mention some values that biodiversity contributes to.

2.8 Case Study

The fish population has been experiencing a significant decline in the coastal ecosystem. Within the coastal ecosystem, various piscine species exist, which carry out a vital function in perpetuating ecological equilibrium. The decreasing quantity of fish gives rise to apprehensions regarding the well-being and consistency of the environment, including potential consequences for nearby societies reliant on fishing as their means of subsistence.

Questions:

1. What factors contribute to the decline in fish population in the coastal ecosystem?
2. How might the decline in fish population affect the overall health and stability of the ecosystem?
3. What are the potential impacts of the declining fish population on the local communities that rely on fishing?

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Unit: 3

Water Pollution

Learning Objectives:

1. Learn about water pollution
2. Understand the pollutants
3. Get known to its sources
4. Learn ways to combat

Structure:

3.1 Sources of Water

Water is regarded as a crucial resource essential for life. It is indispensable for all living beings and would not exist without it. "Source water" refers to bodies of water such as rivers, streams, lakes, reservoirs, springs, and groundwater that supply water to public and private drinking wells.

The main sources of water are surface water and groundwater. These sources, along with rainwater collection, are vital for activities such as drinking, washing, cooking, farming, and various commercial operations. These water sources depend on rainfall and snowfall, both of which are part of the hydrological cycle. Additionally, recycled water can also serve as a source.

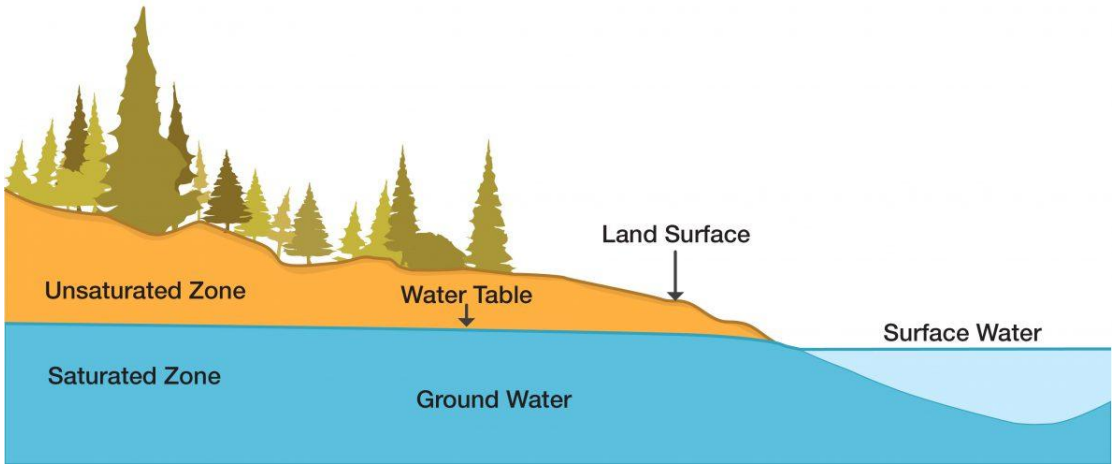

Figure 3.1: Sources of Water

Source: Centre For Disease Control and Prevention

As Figure 3.1 demonstrates, Groundwater is located beneath the Earth's surface in the spaces between rocks and soil. Depending on the depth of the water and the local geology, natural processes may filter out some pollutants and bacteria from groundwater. Groundwater that is drawn from a well often undergoes some treatment before reaching your tap. Surface water accumulates in areas like streams, rivers, lakes, reservoirs, or oceans. The water in these bodies continuously evaporates, infiltrates the groundwater system, and is replenished by precipitation such as rain and snow.

3.1.2 The Water Cycle

The hydrological or water cycle describes the continuous movement of water among the seas, the atmosphere, and the land. Water in oceans, lakes, rivers, and other bodies on land evaporates, turning from liquid to vapor due to the heat of the sun and the wind. Plants also play a role in this cycle through a process called transpiration, where they absorb liquid water and release water vapor through pores in their leaves. This water vapor rises into the atmosphere, carried by upward air currents. As it ascends into cooler regions of the atmosphere, the vapor condenses into droplets, forming clouds. Eventually, these clouds release the water back to the Earth in the form of rain and snow, a process collectively known as precipitation.

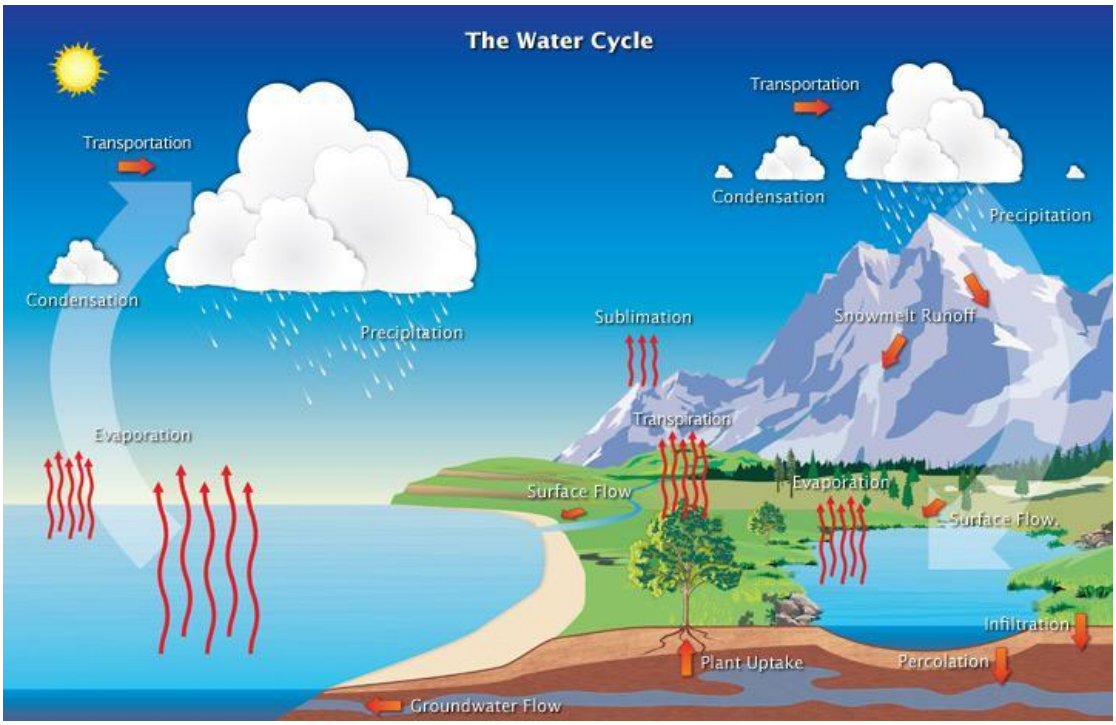

Figure 3.2: Hydrological/Water Cycle

Source: NASA

Rainwater can seep through the soil into underground rocks to become groundwater, or it can flow over the surface as runoff into rivers and streams. Reservoirs hold water, which is moved between them during transfer operations. Continuous water transfer processes include evaporation and transpiration, the movement of water vapor in the atmosphere, precipitation, and the return of water from the land to the sea.

3.2 Water Quality Standards

Access to clean drinking water is essential for health, recognized as a fundamental human right and a cornerstone of effective health protection policies. Various international policy platforms emphasize the importance of water, sanitation, and hygiene for both health and development.

The World Health Organization (WHO) has developed numerous normative guidelines in response to this issue. These guidelines provide official assessments of health risks associated with exposure to harmful substances through water and evaluate the effectiveness of methods to control these risks. WHO recommendations cover a range of areas, including ensuring safe recreational water environments, promoting safe use of wastewater and waste in agriculture and aquaculture, and establishing standards for drinking water quality.

Standards for water quality are made up of three essential parts. To safeguard current uses and high-quality/high-value waters, there are antidegradation regulations, designated uses of a water body, criteria for protecting designated uses, and designated uses themselves.

3.2.1 Water quality standard in India

1. **Drinking Water**

   Drinking water refers to water from any source that is intended for human use, specifically for drinking and cooking. This includes all water supplied for human consumption, whether it has been treated or not. The Bureau of Indian Standards has set the IS 10500:2012 standard as the minimum quality requirement for drinking water in India.

2. **Ground Water**

   The natural chemical composition of groundwater is influenced by the depth of soils and subsurface geological formations with which it interacts. Generally, groundwater across the country is suitable for drinking, farming, or industrial uses. Water from shallow aquifers often contains mixed calcium bicarbonate and is typically appropriate for various uses. However, other types of water, such as those containing sodium chloride, are also present. The quality of groundwater from deeper aquifers

varies by location but is generally deemed acceptable for regular use. Coastal areas often face salinity issues, and there are reports of significant concentrations of fluoride, arsenic, iron, and other heavy metals in isolated areas.

Inland saline issues in groundwater predominantly affect the dry and semi-arid regions of Rajasthan, Haryana, Punjab, Gujarat, Uttar Pradesh, Delhi, Andhra Pradesh, Maharashtra, Karnataka, and Tamil Nadu. While the eastern coast features a short continental shelf characterized by deltaic and estuarine landscapes, the western coast is noted for its extensive continental shelf, which includes backwaters and mud flats. Salinity problems have been documented in many parts of the coastal states of India, with over 110,000 settlements reporting high iron concentrations (>1.0 mg/l) in their groundwater.

Designated-Best-Use	**Class of water**	**Criteria**
Drinking Water Source without conventional treatment but after disinfection	A	• Total Coliforms Organism MPN/100ml shall be 50 or less • pH between 6.5 and 8.5 • Dissolved Oxygen 6mg/l or more • Biochemical Oxygen Demand 5 days 20°C 2mg/l or less
Outdoor bathing (Organised)	B	• Total Coliforms Organism MPN/100ml shall be 500 or less pH between 6.5 and 8.5 Dissolved Oxygen 5mg/l or more • Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
Drinking water source after conventional treatment and disinfection	C	• Total Coliforms Organism MPN/100ml shall be 5000 or less pH between 6 to 9 Dissolved Oxygen 4mg/l or more • Biochemical Oxygen Demand 5

		days 20°C 3mg/l or less
Propagation of Wildlife and Fisheries	D	• pH between 6.5 to 8.5 Dissolved Oxygen 4mg/l or more • Free Ammonia (as N) 1.2 mg/l or less
Irrigation, Industrial Cooling, Controlled Waste disposal	E	• pH between 6.0 to 8.5 • Electrical Conductivity at 25°C micromhos/cm Max.2250 • Sodium absorption Ratio Max. 26 • Boron Max. 2mg/l
	Below-E	Not Meeting A, B, C, D & E Criteria

Table 3.1: Water Quality Criteria
Source: Central Pollution Control Board

3.3 Water Pollutants

Water pollutants can be categorised into four groups, which are as follows:

- Pathogens
- Organic materials
- Inorganic compounds
- Macroscopic pollutants

1. Pathogens: Pathogens include bacteria, viruses, protozoa, and other microorganisms. For example, bacteria are frequently found in water. However, as the number of bacteria rises, the water might become contaminated. Coliform and E Coli bacteria are the two most harmful bacteria.
2. Organic Materials: Carbon-containing molecules make up organic compounds. Methyl tert-butyl ether (MTBE) is a relatively typical volatile organic compound. MTBE was once employed as an air-cleaning gas additive. Although it was later

outlawed, it will take some time for the water to be entirely free of it. Similar to how organic material-containing water can cause lethal illnesses like testicular tumours, leukaemia, kidney and thyroid cancer, lymphoma, and more.

3. Inorganic Materials: While inorganic elements might not be hazardous in modest absorptions, they can become dangerous water pollutants when they mix with other substances in the water. For instance, inorganic materials include heavy metals like copper, arsenic, barium, mercury, zinc, and more.

   Leaching from waste disposal, industrial mishaps, or even increased human activity levels can all contribute to its occurrence. This kind of water contamination also leads to severe health issues in humans and other organisms. Additionally, it can be highly lethal if it is present in larger doses.
4. Macroscopic pollutants: Due to their size and brightness, these kinds of contaminants are particularly noticeable in the water—the most prevalent example of garbage, mainly plastic waste, that finds its way into the sea. Plastic is unlawfully dumped in water because it does not disintegrate. They accumulate in oceans and other bodies of water because they cannot biodegrade.

The following are the leading causes and sources of water pollution:

- Sewage water often contains pathogens and other harmful microorganisms, as well as chemicals that can cause serious health issues.
- Farmers use chemical fertilizers and pesticides to protect their crops, leading to agricultural pollution. When these chemicals enter water sources, they can produce toxic substances harmful to both plants and animals.
- Large oil spills in the ocean can severely harm marine life as the oil does not disperse and affects fish, birds, sea otters, and other marine creatures.
- Industrial activities generate significant waste containing harmful chemicals and pollutants that pollute the environment and pose risks to human health.
- Burning fossil fuels like coal and oil releases ash and other pollutants into the atmosphere, contributing to acid rain when these harmful particles mix with water vapor.

- Household waste materials such as paper, plastic, food scraps, metal, rubber, and glass are often discarded into rivers and the sea, leading to water pollution and detrimental effects on aquatic life.

Figure 3.3: Water Pollution

Source: SibolAlaminos

3.4 Effects of Water Pollution

1. **Health Impacts**: Contaminated water can have severe effects on human health, whether consumed directly or through other means. It can cause diseases such as typhoid, cholera, and hepatitis.
2. **Ecosystem Damage**: Ecosystems are highly sensitive and can be profoundly affected by even small environmental changes. Without proper management of water pollution, entire ecosystems may collapse.

3. **Eutrophication**: Chemicals in water bodies can promote algae growth, leading to thick layers on the surface of ponds or lakes. These algae are then consumed by bacteria, which can deplete the oxygen levels in the water, harming aquatic life.
4. **Impact on Food Chains**: When aquatic creatures absorb toxins and pollutants from the water, and these creatures are then consumed by humans, it can disrupt food chains.

3.5 Summary

- "Source water" refers to bodies of water such as rivers, streams, lakes, reservoirs, springs, and groundwater that provide water for public and private drinking wells.
- The primary sources of water for drinking, washing, cooking, farming, and other commercial uses are surface water, groundwater, and rainwater collection.
- Natural groundwater filtration may reduce some pollutants and bacteria, depending on the water's depth and the local geological conditions.
- Surface water accumulates in locations such as streams, rivers, lakes, reservoirs, or oceans.
- The hydrological cycle, or water cycle, describes the ongoing movement of water among seas, the atmosphere, and land.
- India's minimum water quality standard is defined by IS 10500: 2012, established by the Bureau of Indian Standards.
- Organic compounds are composed of molecules that contain carbon.
- Water contaminated with organic material can lead to serious health issues such as testicular tumors, leukemia, and cancers of the kidney and thyroid, as well as lymphoma.
- A significant oil spill in the ocean that does not disperse can pose a serious threat to marine life, affecting fish, birds, sea otters, and other nearby marine animals.
- If water pollution is not controlled, it could lead to the collapse of entire ecosystems.

3.6 Keywords

- **Source Water**: This term refers to bodies of water such as rivers, streams, lakes, reservoirs, springs, and groundwater that provide water for drinking in both public and private wells.

- **Hydrological Cycle**: This is the ongoing movement of water among oceans, the atmosphere, and land, commonly known as the water cycle.
- **Pathogens**: These include bacteria, viruses, protozoa, and other microorganisms that can cause disease.
- **Eutrophication**: This process involves the enrichment of water bodies with chemicals that boost algal growth, which can negatively impact aquatic ecosystems.

3.7 Self-Assessment Questions

1. Name three primary sources of water that are used for various purposes.
2. How does natural filtration of groundwater help eliminate pollutants and bacteria?
3. What are the environmental impacts of oil spills in the ocean?
4. What are the consequences of uncontrolled water pollution on ecosystems?
5. 5. Mention any three sources of water pollution.
6. 6. Categorise water pollutants of them in brief.
7. Explain the concept of eutrophication and its role in water pollution.
8. Evaluate the effectiveness of various water pollution prevention and control measures, such as wastewater treatment plants, watershed management, and regulatory policies. Discuss the challenges and limitations associated with implementing these measures.
9. Analyse how economic activities, industrialisation, urbanisation, and agricultural practices contribute to water pollution and propose strategies for sustainable water management that consider social and economic dimensions.
10. Examine the role of emerging contaminants in water pollution and their potential long-term implications.

3.8 Case Study

India faces a severe problem with water pollution, which the Yamuna River best demonstrates. This precious water has become contaminated due to rapid industry and urbanisation. Industrial effluents, untreated sewage, and solid waste dumping have produced high amounts of harmful pollutants, harming human health and the river's ecosystem. Aquatic biodiversity has decreased, and waterborne illnesses have grown widespread. Effective solutions necessitate sustainable industrial practices, improved wastewater treatment, and

community involvement, notwithstanding government initiatives like the Yamuna Action Plan. India must take extensive action to combat water pollution to protect this precious resource.

Questions:

1. How have rapid urbanisation and industrialisation contributed to the contamination of the Yamuna River in India? Discuss the sources of pollutants and their impact on human health and the river's ecosystem.
2. What are the consequences of water pollution in the Yamuna River for surrounding communities?
3. Explain the prevalence of waterborne diseases and their effects on the local population.

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Unit: 4

Air Pollution

Learning Objectives:

- Learn about Air Pollution
- Understand its sources
- Understand its effects
- Know about the air quality standard

Structure:

4.1 Composition of Atmosphere

A planet's atmosphere comprises one or more layers of gases held in place by the planet's gravity. The earth retains its atmosphere when the gravity is strong and the atmosphere's temperature is low.

In addition to nitrogen (78%), argon (0.9%), carbon dioxide (0.04%), and other gases, oxygen constitutes 21% of the Earth's atmosphere. The presence of water vapor in the atmosphere varies with altitude, typically around 1% at sea level. Carbon dioxide is a significant contributor to the greenhouse effect, absorbing outgoing terrestrial radiation while remaining transparent to incoming solar energy. It absorbs some of the Earth's radiation and reflects a portion back towards the surface.

Dust particles, originating from various sources such as fine dirt, smoke, soot, pollen, and meteorite fragments, are also present in the atmosphere. Water vapor condenses around these dust and salt particles, forming clouds that serve as hygroscopic nuclei.

4.1.1 Gases in the Atmosphere

1. **Carbon Dioxide**

   In meteorology, carbon dioxide plays a critical role. It is opaque to outgoing terrestrial radiation but transparent to incoming solar radiation (insolation). Carbon dioxide filters out terrestrial radiation and reflects some of it back towards the planet's surface. The primary driver of the greenhouse effect is carbon dioxide. Even if the amount of other gases in the atmosphere has stayed constant over the past few decades, the volume of carbon dioxide has been rising principally due to the burning of fossil fuels. This increasing carbon dioxide concentration is the main contributor to global warming.

2. **Nitrogen**

   Nitrogen makes up about 78% of the atmosphere, but using nitrogen straight from the air is impossible.

   Proteins are also made by biotic organisms using nitrogen. The nitrogen needed by living organisms is provided through the nitrogen cycle.

3. **Oxygen**

   21% of the air is made up of oxygen. All living things need it, as breathing depends on it. It is also essential for burning.

4. **Argon**

   0.9% of the atmosphere is made up of argon. Their primary application is in light bulbs.

5. **Ozone Gas**

   Ozone is another crucial component of the atmosphere, primarily located between 10 and 50 kilometers above the Earth's surface. It acts as a shield, absorbing the sun's ultraviolet radiation and preventing it from reaching the Earth's surface. The ozone layer in the stratosphere is the only part of the atmosphere that contains a significant amount of ozone gas.

4.2 Air Quality Standards

An air quality standard defines clean air as the level of a contaminant present in outdoor air that does not pose a risk to public health over a specified period. National Ambient Air Quality Standards (NAAQS) are guidelines for air quality set by the Central Pollution Control Board (CPCB) and applied nationwide.

Efficient management of ambient air quality relies on these standards. Established in 1982 following the Air Act, the first ambient air quality standards underwent revisions in 1994. The most recent revision of the NAAQS occurred in 2009.

The 2009 standards standardized national guidelines and lowered the maximum permissible levels of contaminants. Previously, industrial zones faced less stringent regulations compared to residential areas. The National Air Quality Monitoring Programme (NAMP) monitors compliance with NAAQS, overseen by the CPCB.

4.3 Sources and Effects of Air Pollution

4.3.1 Sources

The primary categories of sources of air pollution include:

1. Mobile Sources: These include vehicles such as cars, trucks, buses, motorcycles, and airplanes. Mobile sources emit pollutants like nitrogen oxides (NOx), carbon monoxide (CO), volatile organic compounds (VOCs), and particulate matter (PM) through combustion of fossil fuels.

2. Stationary Sources: These are fixed facilities that emit pollutants into the atmosphere. They include power plants, industrial facilities, refineries, factories, and residential heating systems. Stationary sources emit a variety of pollutants, including sulfur dioxide (SO2), nitrogen oxides (NOx), particulate matter (PM), volatile organic compounds (VOCs), and hazardous air pollutants (HAPs).

3. Area Sources: These are smaller sources of pollution that emit pollutants over a broad area. They include residential heating, commercial cooking, agriculture, construction, and open burning of waste. Area sources emit pollutants such as particulate matter (PM), volatile organic compounds (VOCs), and hazardous air pollutants (HAPs).

4. Natural Sources: These include natural processes and events that emit pollutants into the atmosphere. Examples include wildfires, volcanic eruptions, dust storms, and biogenic emissions from vegetation. Natural sources can emit pollutants such as particulate matter (PM), sulfur dioxide (SO2), nitrogen oxides (NOx), and volatile organic compounds (VOCs).

These primary categories encompass a wide range of sources that contribute to air pollution, impacting both local and regional air quality.

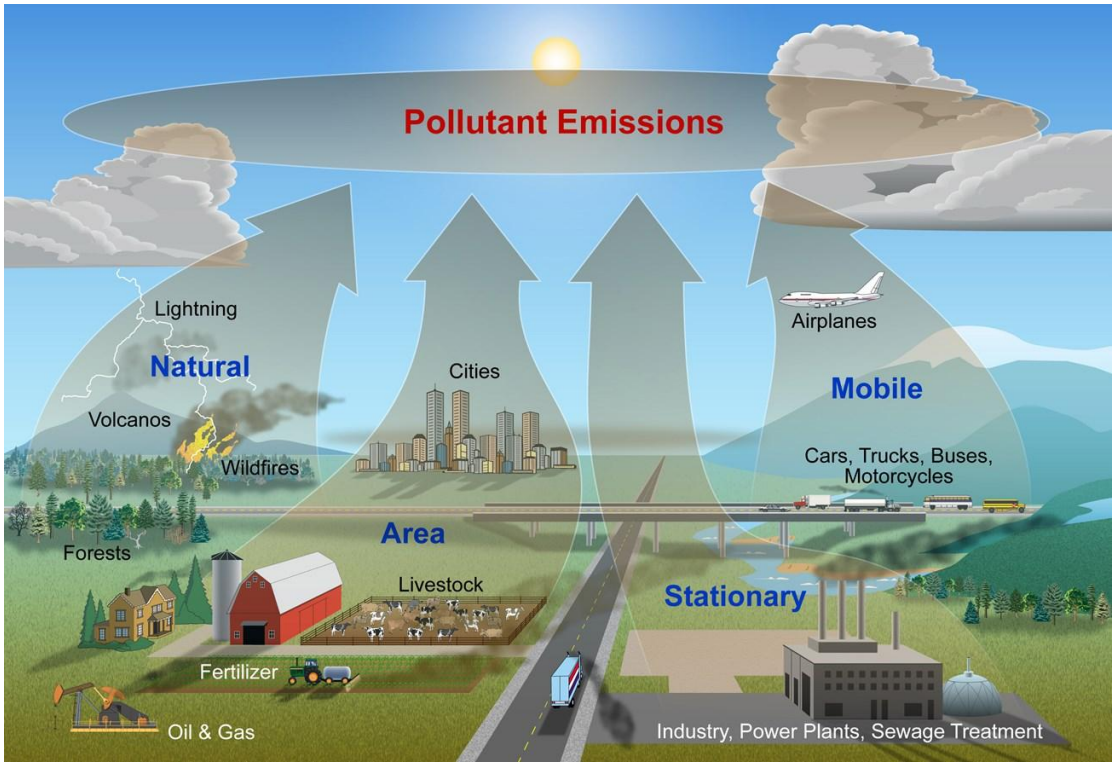

Figure 4.1: Air Pollutants
Source: National Park Service

Two categories of air contaminants are:

1. **Primary Pollutants**: These are substances that are directly emitted into the atmosphere and contribute to air pollution. One significant primary pollutant is sulfur dioxide, which is released by manufacturing processes.

2. Secondary Pollutants: These are pollutants that are formed when primary pollutants react with each other or with other substances in the atmosphere. For example, when smoke from burning fossil fuels reacts with fog, it can produce smog, which is a secondary pollutant.

Causes of Air Pollution:

1. Fossil Fuels: Burning fossil fuels releases sulfur dioxide into the atmosphere. Inefficient combustion of fossil fuels also produces carbon monoxide, contributing to air pollution.

2. Automobiles: Vehicle emissions, including those from trucks, cars, buses, and jeeps, are major contributors to air pollution. These emissions not only harm the environment but also pose health risks to humans and contribute to greenhouse gas emissions.

3. Farmers' Activities: Agricultural operations release hazardous substances such as ammonia from fertilizers. Chemicals from insecticides, pesticides, and fertilizers also contribute to air pollution.

4. Industries and Factories: Industrial processes and manufacturing release pollutants such as carbon monoxide, organic compounds, hydrocarbons, and chemicals, which degrade air quality.

5. Mining Operations: Mining activities release dust and chemicals into the air, posing health risks to workers and nearby populations.

6. Domestic Sources: Household activities such as painting and using household cleaning products can release toxic chemicals into the air. Freshly painted walls can emit volatile organic compounds, affecting indoor air quality and respiratory health.

These sources collectively contribute to air pollution, impacting both human health and the environment.

4.3.2 Effects of Air Pollution

The adverse effects of air pollution on the environment are manifold:

1. Diseases: Air pollution contributes to respiratory and cardiovascular illnesses, including lung cancer. Children living in polluted areas are more susceptible to asthma and pneumonia. Each year, air pollution is responsible for numerous deaths, both directly and indirectly.

2. Global Warming: Emissions of greenhouse gases lead to an imbalance in the composition of the atmosphere, causing global warming. This rise in temperature results in rising sea levels, melting glaciers, and inundated areas. Factors contributing to global warming include deforestation, vehicle emissions, chlorofluorocarbon (CFC) usage, industrial activities,

agricultural practices, overpopulation, volcanic eruptions, and increased water vapor in the atmosphere.

3. Acid Rain: Combustion of fossil fuels releases sulfur and nitrogen oxides, which react with water droplets in the atmosphere, forming acid rain. Acid rain has detrimental effects on ecosystems, washing away essential nutrients for plant growth, harming respiratory systems of humans and animals, corroding water pipes, and damaging structures and historical landmarks.

4. Ozone Layer Depletion: The ozone layer, located in the lowest part of the atmosphere, protects Earth from harmful UV radiation. Depletion of the ozone layer, primarily caused by the release of hydrochlorofluorocarbons (HCFCs), halons, and chlorofluorocarbons (CFCs), results in increased incidence of skin diseases and eye problems due to exposure to UV radiation.

These environmental impacts underscore the urgent need for measures to reduce air pollution and mitigate its harmful effects on both human health and the planet.

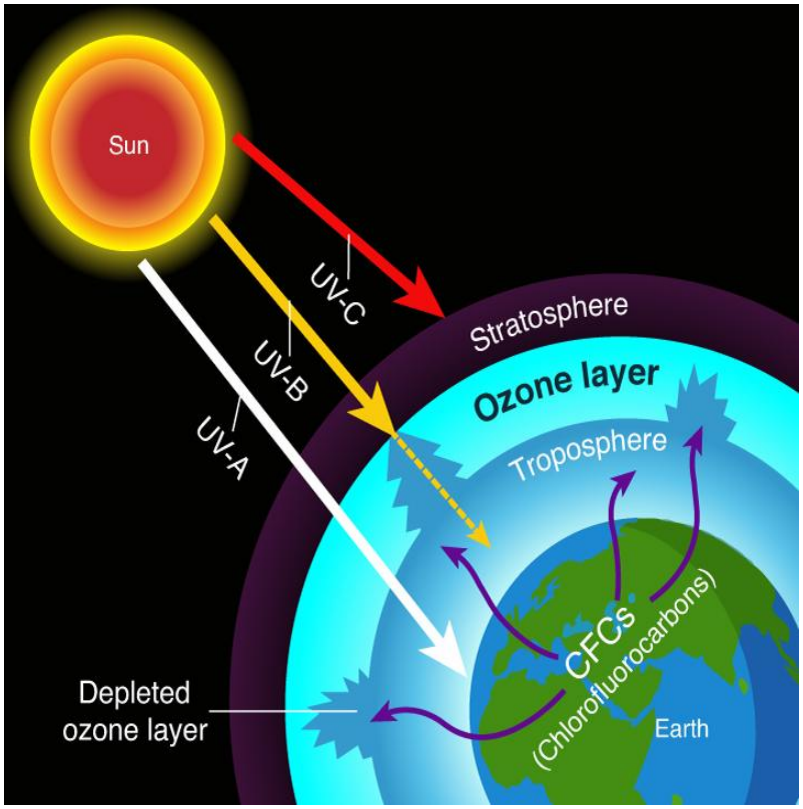

Figure 4.2: Ozone Layer Depletion
Source: Science Facts

The depletion of the ozone layer has several negative impacts on the environment:

1. **Effects on Human Health:** Deterioration of the ozone layer exposes humans to harmful UV radiation from the sun, leading to health issues such as cancer, skin disorders, cataracts, sunburns, premature aging, and weakened immune systems.

2. **Effects on Animals:** Direct exposure to UV radiation can cause skin and eye cancer in animals.

3. **Environmental Impacts:** Intense UV radiation can inhibit plant growth, flowering, and photosynthesis. Forests are also affected by the damaging effects of UV radiation.

4. **Marine Life:** Plankton, a crucial component of the aquatic food chain, is significantly impacted by excessive UV radiation. The decline in plankton populations also affects other species in the marine ecosystem.

Another major contributor to air pollution is the greenhouse effect, which involves various greenhouse gases. Greenhouse gases such as carbon dioxide, methane, and water vapor absorb infrared radiation emitted from the Earth's surface and reradiate it back, contributing to the trapping of heat in the atmosphere.

The greenhouse effect operates similarly on Earth to the way a greenhouse functions, where gases in the atmosphere, like carbon dioxide, trap heat. During the day, sunlight penetrates the atmosphere, heating the Earth's surface. At night, the Earth's surface cools, releasing heat back into the atmosphere. However, greenhouse gases in the atmosphere capture some of this heat, helping to maintain the planet's average temperature at approximately 58 degrees Fahrenheit (14 degrees Celsius).

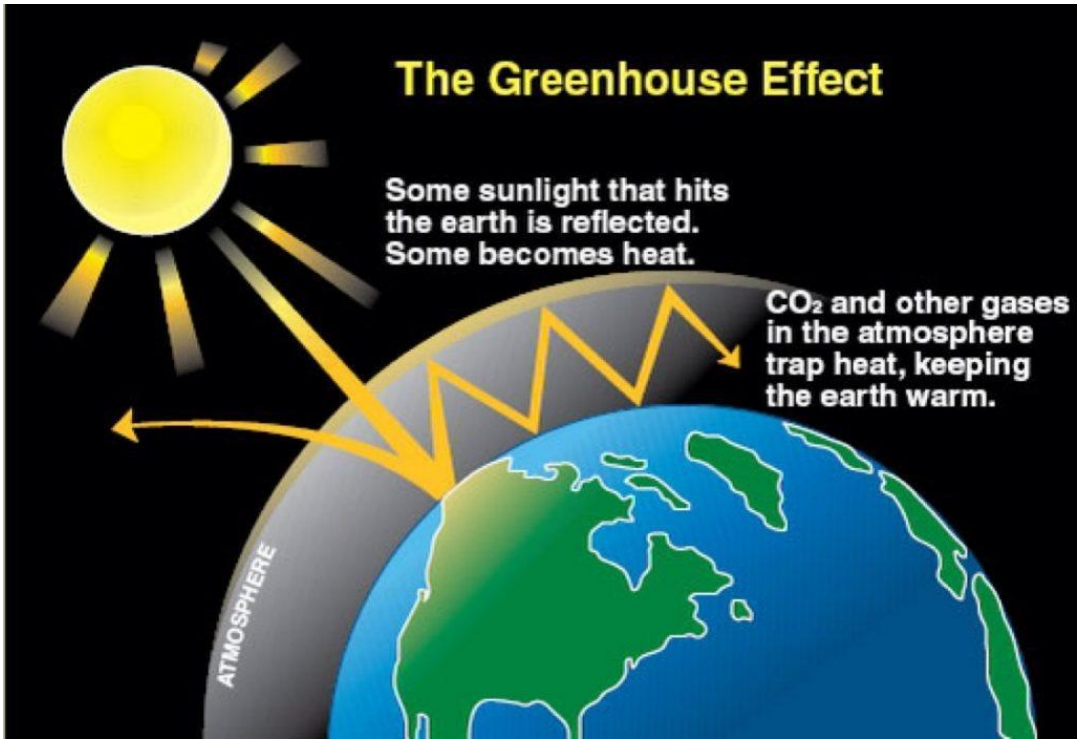

Figure 4.3: Greenhouse Effect

Source: Medium

There are two types of causes of the greenhouse effect.

Natural: The sun makes the earth habitable. 70% of the solar energy that reaches our planet passes through the atmosphere, with just 30% of it being reflected in space. The earth's surface, oceans, and atmosphere reflect and heat the gas. The heat is then returned by reflection.

Human-Induced: A portion of rays reflected during the natural greenhouse effect is reflected into space. Nearly 90% of it is taken up by greenhouse gases. This causes the gases to reflect more heat towards the earth, increasing its warmth.

4.4 Summary

1. **Atmospheric Composition**: The atmosphere consists of layers of gases held in place by a planet's gravity. Strong gravity results in one or more layers of gases surrounding the planetary body.

2. **Carbon Dioxide in Meteorology:** Carbon dioxide plays a crucial role in meteorology. It is opaque to emitted terrestrial radiation but transparent to incoming solar radiation, known as insolation.

3. **Air Quality Standards:** Air quality standards define clean air as the level of contaminants in outdoor air that does not pose a risk to public health over a specified period.

4. **Sulphur Dioxide Emissions:**Sulphur dioxide is released into the atmosphere during the combustion of fossil fuels. Additionally, carbon monoxide is produced when fossil fuels are burned inefficiently, contributing to air pollution.

5. **Industrial Sources of Pollution:** Industry and manufacturing activities are significant sources of air pollution, emitting carbon monoxide, organic compounds, hydrocarbons, and various chemicals into the atmosphere.

6. **Ozone Layer Depletion:** The release of hydrochlorofluorocarbons (HCFCs), halons, and chlorofluorocarbons (CFCs) into the atmosphere is the primary cause of thinning in the ozone layer, which protects the Earth from harmful UV radiation.

4.5 Keywords

1. **Atmospheric Composition**: The atmosphere consists of layers of gases held in place by a planet's gravity. Strong gravity results in one or more layers of gases surrounding the planetary body.
2. **Air Quality Standards:** Air quality standards define clean air as the level of contaminants in outdoor air that does not pose a risk to public health over a specified period.
3. **National Ambient Air Quality Standards:** The Central Pollution Control Board (CPCB) established and used these air quality guidelines nationwide.
4. **Greenhouse Gas:** A greenhouse gas refers to any gas capable of absorbing infrared radiation, also known as net heat energy, emitted from the Earth's surface and re-emitting it back to the surface. These gases contribute to the greenhouse effect, which

leads to the trapping of heat in the Earth's atmosphere, thereby influencing global climate patterns.

4.6 Self-Assessment Questions

1. What are the two most abundant gases in the Earth's atmosphere, and what are their respective percentages?
2. Explain the relationship between fossil fuel combustion and the release of sulphur dioxide and carbon monoxide release into the atmosphere. How do these pollutants contribute to air pollution?
3. Discuss the role of hydrochlorofluorocarbons, halons, and chlorofluorocarbons in the depletion of the ozone layer. How do these emissions impact the atmospheric environment, and what are the potential consequences of ozone layer depletion?
4. Explain the phenomenon of acid rain and its connection to air pollution. What are the primary pollutants responsible for acid rain, and what are this phenomenon's environmental and ecological impacts?
5. Describe the impact of air pollution on climate change. How do greenhouse gases and air pollutants interact to influence the Earth's climate, and what are the consequences of this interaction?
6. What are the primary sources of air pollution, and how do they contribute to the deterioration of air quality?
7. Explain the role of industrial activities in air pollution.
8. Discuss the primary pollutants emitted during combustion and their environmental and health impacts.
9. What are the primary greenhouse gases responsible for the enhanced greenhouse effect, and how do they contribute to global warming? Discuss their sources.
10. What are the primary substances responsible for ozone depletion, and how do they affect the ozone layer?

4.7 Case Study

The 1980s saw a significant acid rain outbreak in the Scandinavian region, which hurt the ecology. Wind currents brought industrial emissions from nearby nations, especially sulphur dioxide and nitrogen oxides, precipitating acid rain in Norway, Sweden, and Finland. Acid

rain caused lakes and rivers to become more acidic, which killed aquatic life and reduced biodiversity. In addition, woods were harmed by acid rain, which inhibited tree development and caused a loss of foliage. The forestry and fishery industries experienced losses, having a considerable negative economic impact. The afflicted nations established stricter emission limits and international partnerships to reduce pollution emissions to fight this problem.

Questions:

1. Describe the environmental impacts of acid rain on aquatic ecosystems in the Scandinavian region during the 1980s. How did the acidification of lakes and rivers affect marine life and biodiversity in the affected areas?
2. Explain the consequences of acid rain on forest ecosystems in Norway, Sweden, and Finland. Discuss the specific damages caused to forests, including the effects on foliage and tree growth and the subsequent economic implications for the forestry industry.
3. Discuss some measures to prevent or reduce acid rain possibilities.

4.8 References

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Unit: 5

Noise Pollution

Learning Objectives:

1. Know about Noise Pollution in detail
2. Understand its sources
3. Learn about its effects
4. Learn ways to control noise pollution

Structure:

5.1 Noise Pollution: Introduction

Noise pollution refers to any disruptive sound that negatively impacts the health and well-being of people and other species. According to the World Health Organization (WHO), noise pollution is generally considered to be present at sound levels exceeding 65 decibels (dB). Generally, noise becomes uncomfortable at 75 dB and can be harmful at levels reaching 120 dB. It is recommended that noise levels be maintained below 65 dB during the day. Research indicates that noise levels above 30 dB at night can interfere with sleep quality.

5.1.1 Noise Pollution – Types

The three categories of pollution are as follows:

- Vehicle Noise
- Residential Noise
- Industrial Noise

Vehicle Noise

It primarily consists of traffic noise, which has been louder in recent years as more cars have been on the road. The increase in noise pollution causes age-related hearing loss, headaches, hypertension, and other problems.

Residential Noise

It includes noise made by appliances, household tools, etc. The primary sources are things like speakers, transistors, and musical instruments.

Industrial Noise

The loud noise is a result of the heavy industrial machinery. Numerous studies have found that industrial noise pollution reduces hearing capacity by 20%.

5.2 Levels of Noise

The likelihood of developing hearing loss rises with both the volume and duration of exposure to sound. Prolonged exposure to loud noises, especially without hearing protection or adequate breaks for your ears, increases the risk significantly. For example, the noise from a motorcycle engine is about 95 dB, which is much louder than a normal conversation (around 60 dB) or a whisper. Continuous exposure to noise levels above 70 dB can start to harm your hearing, while sounds exceeding 120 dB can cause immediate damage to your ears.

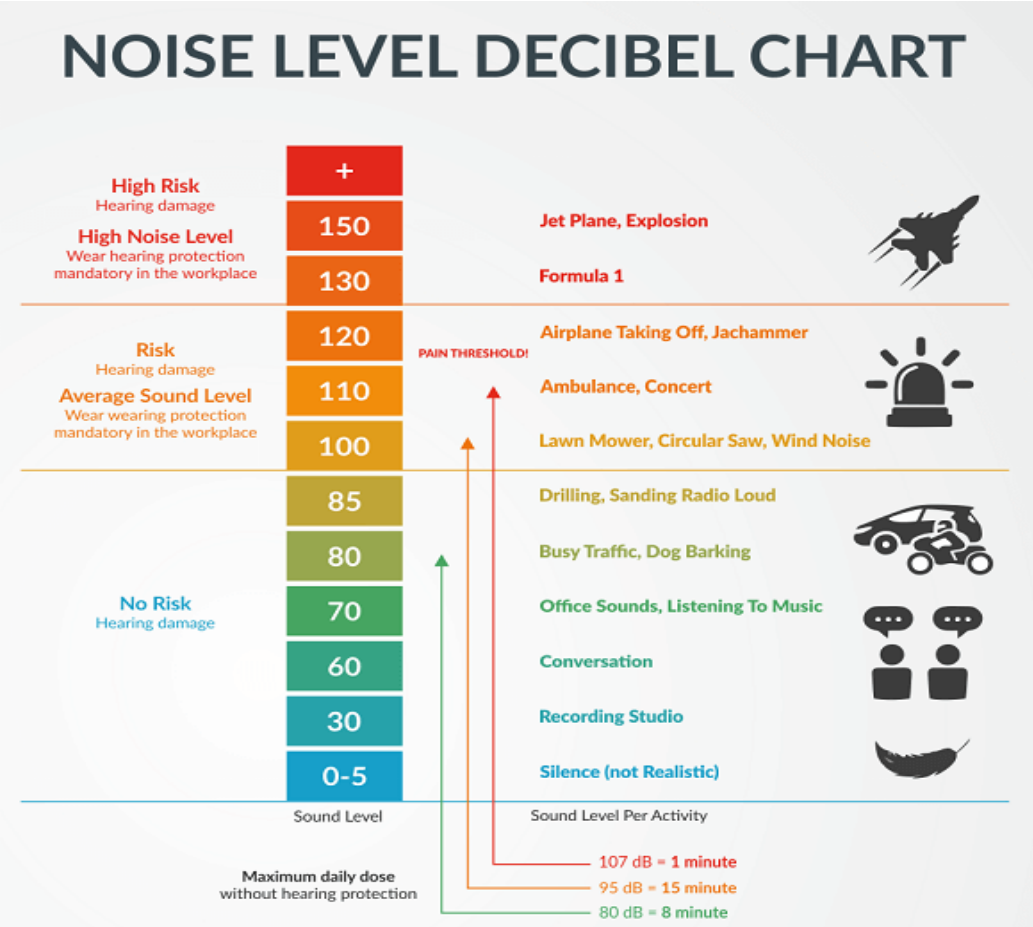

Figure 5.1: Noise Level Decibel Chart

Source: Electronics Hub

Figure 5.1 demonstrates the noise level produced by different human activities and instruments.

5.2.1 Noise Exposure Limits

Occupational hazards such as noise are well known and must be managed.

Occupational exposure limits for noise in the workplace are put into place to achieve this. As each nation has noise exposure limitations, professionals must check the local legislation to determine the standards established for the country where their firm conducts business.

Country	8-hr average dB(A) exposure	The Upper limit for peak sound pressure level
China	70-90	115
India	90	140
Netherlands	85	140
Poland	85	135
United Kingdom	85	140
USA	90	140

Table 5.1: Noise Limitations By Different Countries

Source: IOSH

The standard guideline for acceptable noise exposure varies by country, but a time-weighted average (TWA) of 85 decibels (dB A) is commonly recognized. TWA assesses the average exposure level a worker encounters to noise hazards over a specific period, such as an 8-hour workday or a 40-hour workweek, to ensure that the exposure does not lead to harmful or severe effects.

5.3 Sources and Effects of Noise Pollution

5.3.1 Sources/Causes

- **Industrialization**

  Many industries use large machinery that produces significant noise, further amplified by equipment such as grinding mills, exhaust fans, compressors, and generators.

- **Lack of Urban Planning**

  In several developing countries, poor urban planning exacerbates noise pollution. Overcrowded living conditions, disputes over parking, and conflicts over essential resources contribute to the problem. Proximity of residential areas to industrial sites can also increase noise pollution in urban areas, affecting residents' well-being.

- **Social Events**

  Social gatherings often generate high levels of noise. Events like weddings, parties, pub gatherings, discos, and religious services can disturb local communities, especially when noise regulations are not followed.

- **Transportation**

  Transportation systems, including cars, airplanes, and subways, produce substantial noise, which can be disruptive to residents' daily lives.

- **Construction Activities**

  Construction activities are widespread, involving projects like mining, bridge building, dam construction, and roadwork. Both construction workers and nearby residents are exposed to significant noise, which can adversely affect hearing over prolonged periods.

- **Household Activities**

  Daily household activities involve the use of various noisy appliances such as TVs, mobile phones, mixer grinders, pressure cookers, vacuum cleaners, washing machines, dryers, coolers, and air conditioners. While these sounds may seem minor individually, collectively they contribute to noise pollution, impacting the quality of life in neighborhoods.

- **Air Traffic Noise**

  Air travel also contributes to noise pollution, with a single airplane generating up to 130 dB of noise, affecting communities near airports.

5.3.2 Effects of Noise Pollution

- **Hearing Issues**

  Exposure to sounds that our ears aren't designed to filter can lead to health problems. Continuous exposure to loud noises can result in hearing loss, damage to the eardrum, and conditions such as tinnitus or deafness. It can also diminish our ability to detect natural sounds that help regulate bodily functions like heartbeat.

- **Psychological Problems**

  Excessive noise pollution can adversely affect psychological health in various environments, including workplaces, construction sites, pubs, and homes. Research indicates that high noise levels can lead to aggressive behavior, sleep disturbances, chronic stress, fatigue, depression, anxiety, hysteria, and hypertension in both humans and animals. Increased noise tends to make individuals more irritable and less patient, potentially leading to severe health issues later in life.

- **Physical Issues**

  Prolonged exposure to loud noise can contribute to physical health problems such as gastritis, colitis, and even heart attacks. Noise pollution is associated with headaches, increased blood pressure, respiratory irritation, and rapid heart rate.

- **Cognitive Problems &Behavioural Modifications**

  Noise can impact brain activity and concentration, potentially leading to decreased performance over time. Excessive noise can dull cognitive functions and slow reaction times. It can also interfere with memory, posing challenges for learning. Research has shown that children living near airports or busy roads often face learning difficulties, frequent headaches, increased use of sedatives and sleeping pills, a higher likelihood of minor accidents, and a greater need for mental health services.

- **Insomnia Disorders**

  High noise levels can disrupt sleep, leading to fatigue and discomfort. Inadequate sleep can affect performance both at work and at home.

- **Cardiovascular Issues**

  There is an increasing prevalence of cardiovascular diseases, high blood pressure, and heart issues related to stress. Studies have shown that loud noise can disrupt regular blood flow, raising blood pressure and heart rate.

- **Impact on Wildlife**

  Noise pollution has a significant impact on wildlife. Research from Biology Letters indicates that excessive noise affects various animals, with disruptions starting at home. Pets in noisy environments often exhibit more aggressive responses.

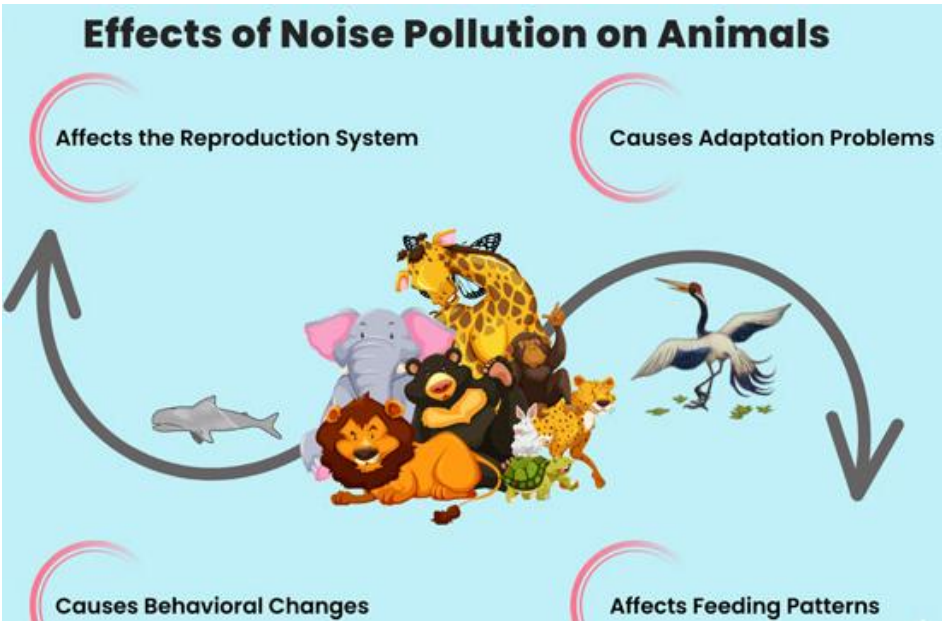

Figure 5.2: Effects of Noise Pollution on Animals

Source: Earth Reminder

They have a lot of behavioral problems and are more likely to lose their way. Hearing loss is a common occurrence in wild animals, making them easy prey and contributing to population decreases. Others become less adept hunters, disrupting the natural balance of the ecosystem.

5.4 Prevention of Noise Pollution

The World Health Organization emphasizes the need for awareness in addressing noise pollution. Although there are limited options currently available for reducing noise pollution, governments can play a crucial role in several ways:

- Implementing regulations that include both preventive and corrective measures.
- Protecting specific areas such as rural regions, natural reserves, and city parks to manage noise pollution.
- Managing the distance between residential zones and noise sources like airports to minimize exposure.
- Creating pedestrian-only zones to reduce vehicle noise, allowing vehicle access only for essential purposes.
- Enforcing penalties for exceeding noise limits.
- Regulating the noise levels in entertainment venues such as pubs, clubs, events, and discos.
- Removing public loudspeakers to decrease noise pollution.
- Designing urban environments to establish "No-Noise" zones where industrial and vehicular noise is minimized.
- Achieving a reduction in traffic noise by replacing conventional asphalt with more effective materials.

Individuals can also take steps to reduce noise pollution:

- Monitor and reduce personal noise levels in your surroundings.
- Choose living areas with abundant vegetation, as trees can reduce noise levels by 5 to 10 dB.
- Lower the volume on televisions, music systems, and radios at home.
- Avoid noisy recreational activities and visits to loud places.
- Use appropriate noise absorbers for noisy equipment.
- Wear headphones when listening to music.
- Use earplugs in noisy environments to decrease overall noise exposure.
- Opt for electric vehicles or bicycles to reduce traffic noise.
- Regularly maintain your vehicle, including proper lubrication, to minimize noise.
- Incorporate noise-absorbing materials in the construction of your home.

5.5 Summary

- Noise pollution refers to any disruptive sound that negatively impacts the health and well-being of both humans and other species.
- According to the World Health Organization (WHO), noise pollution is identified as noise levels exceeding 65 dB.
- Prolonged exposure to noise, especially without adequate hearing protection or sufficient breaks, increases the risk of hearing loss.
- A commonly accepted standard in many places is a time-weighted average (TWA) of 85 dB (A), reflecting average noise exposure levels over time.
- TWA measures the average exposure to harmful conditions like noise, accounting for the frequency and duration of exposure over a defined period.
- In urban areas, noise pollution can arise when residential and industrial zones are in close proximity, potentially disrupting residents' well-being.
- Excessive noise can affect brain function and concentration, leading to decreased performance over time. Just like other sound waves, high noise levels can impair cognitive functions and slow down reaction times.

5.6 Keywords

- **Noise Pollution:** Any upsetting sound that interferes with people's and other species' health and well-being is called noise pollution.
- **Time-weighted average:** • It measures the average frequency at which an employee is exposed to an unfavorable situation, such as noise, over a predetermined length of time. This is a method of measuring an employee's daily exposure to hazards, such as noise.
- **Psychological problems:** These include aggressive behaviour, sleep disruption, ongoing stress, weariness, sadness, anxiety, hysteria, hypertension, etc.
- **Ecological Equilibrium:** It is a dynamic equilibrium within an organismal community when genetic, species and ecosystem diversity stay largely stable and are only gradually changing due to natural succession.

5.7 Self-Assessment Questions

1. What are the familiar sources of noise pollution in urban environments?
2. How does noise pollution impact human health and well-being?
3. What simple measures can individuals take to reduce noise pollution in their daily lives?
4. How does prolonged exposure to noise pollution contribute to chronic health conditions?
5. How can urban planning and architectural design contribute to minimising the impacts of noise pollution on human health and well-being?
6. What is the concept of time-weighted average (TWA), and how is it used to assess noise exposure?
7. What are the cognitive effects of noise pollution on brain activity and concentration levels?
8. What is the generally accepted benchmark for noise exposure in occupational settings?
9. How does the World Health Organisation define noise pollution?
10. What is the recommended noise level threshold set by the WHO?

5.8 Case Study

A study examined how noise pollution affects avian behaviour and communication among urban bird species. Field research showcased that loud anthropogenic noise interferes with bird vocalisations, which impacts mate attractiveness, territorial defence, and breeding success. Additionally, stress reactions brought on by noise affect foraging habits and lower foraging effectiveness. The study emphasised the necessity for noise reduction measures to save urban bird populations and their ecological integrity.

Questions:

1. How does noise pollution affect the communication and behaviour of wildlife species in urban environments?
2. What are the observed effects of noise pollution on the reproductive success and breeding behaviours of animals in urban areas?

3. In what ways does noise pollution influence the foraging patterns and ecological interactions of wildlife species within urban ecosystems?

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Unit: 6

Solid Waste Management

Learning Objectives:

- Learn about Solid Waste Management
- Learn to classify waste
- Understand its composition
- Know its characteristics

Structure:

6.1 Municipal Waste- Introduction

Any undesired material in our environment or from everyday products that is neither liquid nor gas is considered solid waste. These wastes need to be disposed of carefully by following recognised protocols. Solid waste management has been an issue due to improper disposal for as long as people have lived in towns and neighbourhoods.

The complete process of collecting, treating, and disposing of solid waste is called "solid waste management". This waste management process involves gathering and disposing of wastes from diverse sources.

Figure 6.1: Solid Waste Management

Source: Netsol Water

Municipal Solid Waste

Common items abandoned by the general population are included in municipal solid waste (MSW). Municipal solid waste composition differs substantially between municipalities and changes significantly over time.

Persistent wastes like plastic film and non-recyclable packaging make up most trash streams in cities with well-developed waste recycling systems. Municipal solid waste categories eliminate industrial, agricultural, medical, and radioactive waste and sewage sludge. The municipality is in charge of collecting trash within a given area.

The term "residual waste" describes garbage from residential sources that have not been moved or separated for processing.

6.2 Classification of Solid Waste

There are two main categories in which solid waste can be categorised- Biodegradable and Non-Biodegradable. At the same time, Municipal Solid waste consists of both, some other types of substantial waste fall under the two. Some of them are mentioned below.

Figure 6.2: Classification of Solid Waste

Source: INTOSAI

- **Dangerous waste**

"Hazardous waste" describes a specific category of dangerous material. Industrial and medical waste are regarded as hazardous because they contain harmful substances.

Toxic, incredibly flammable, or explosive, hazardous wastes can damage people, pets, and plants.

Hazardous household waste includes old batteries, shoe polish, paint cans, pharmaceutical containers, and medicine bottles.

Hazardous waste in the industrial sector is mainly produced by the metalsrubber products, chemical, paper, dye, pesticide, and refining industries. It is possible to die from direct exposure to poisonous waste materials like cyanide and mercury.

- **Hospital trash**

Hospital trash is generated when biological products are studied, developed, and tested, as well as when people or animals are vaccinated, treated, or diagnosed.

Contaminated waste, disposables, cultures, abandoned pharmaceuticals, chemical wastes, contaminated trash, bandages, swabs, body fluids, and human excreta are some examples of what may fall under this category.

These are extremely contagious and, if not handled carefully and scientifically, might seriously endanger human health.

Blood, sharps, unwanted microbiological cultures and stocks, identifiable body parts (such as those related to amputations), extra human or animal tissue, used bandages and dressings, discarded gloves, and other medical supplies that may have come into contact with bodily fluids or blood are examples of infectious hospital waste.

- **Wastes from Construction and Demolition**

Wastes from construction and demolition are materials left over after constructing, renovating, repairing, or demolishing homes, businesses, as well as additional structures. Earth, stones, concrete, bricks, timber, roofing, plumbing, heating, and electrical supplies, as well as fragments of the general municipal waste stream, make up the majority of it. Large-scale production of it at construction and demolition sites, however, usually results in its removal by vendors for the purpose of filling low-lying areas and by urban local bodies for disposal at landfills.

- **Industrial Wastes**

This category includes the solid waste left behind after manufacturing and other industrial processes. They have a wide variety of compounds. They are treated differently from municipal wastes due to this. However, municipal landfills commonly receive and dispose of solid wastes from small industrial operations and ash from power plants.

• Waste Water

Solid byproducts of sewage treatment are called sewage wastes. They come from the processing of sewage, both treated and untreated, that contains organic sludge. They are primarily organic. Grit, an inorganic component of raw sewage that is isolated during the first stage of treatment, must be buried or disposed of right away because it entraps putrescible organic materials that could contain infections. Most treated, dewatered sludge can be used to improve soil, but doing so is only sometimes cost-effective. Therefore, unless specific planning is done for disposal, the solid sludge enters the municipal trash stream.

6.3 Composition of Solid Waste

The kind of waste is one of the most important factors influencing emissions from solid waste treatment because different waste types contain varied amounts of fossil and degradable organic carbon. Different countries and regions have quite different waste compositions and classification systems used to collect data on waste composition in municipal solid trash.

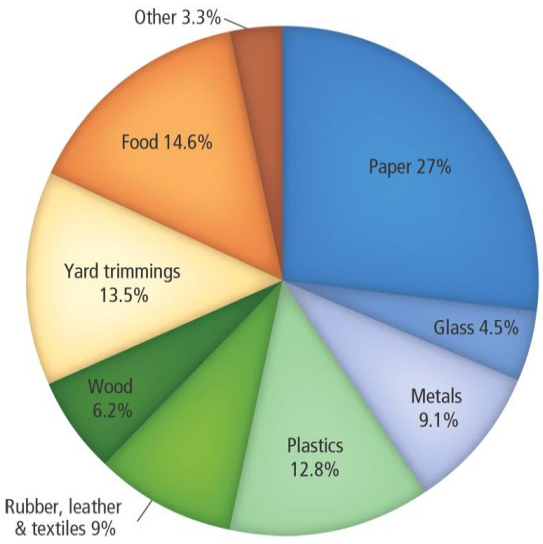

Figure 6.3: Composition of Municipal Solid Waste

Source: EPA

Wastes such as food, textiles, paper, and yard waste are all degradable. Non-fossil carbon is also present in small amounts in ash, dust, rubber, and leather but is hardly biodegradable. The majority of the fossil carbon in MSW is found in some textiles and plastics (particularly plastics found in disposable diapers). Small amounts of fossil carbon can also be found in paper and synthetic leather.

Plastic trash, commonly referred to as plastic pollution, is the build-up of plastic objects (such as plastic bottles and other items) in the ecosystem of Earth that negatively impacts wildlife habitats, humans, and animals.

Chemical Composition of Solid Waste

- Heat content, called calorific value, is the quantity of heat energy created when the trash is burned.
- Moisture content is the amount of water in the waste
- Ash content is the amount of material left over after burning the waste

6.4 Characteristics of Solid Waste

The characteristics of Solid Waste are divided into two categories: Physical Characteristics and Chemical Characteristics.

- **Physical Characteristics**

The physical characteristics of waste are

- Density

The mass of the waste per unit volume (kg/m3), or the density of the waste, is a crucial factor to take into account when constructing a solid waste management system, which includes creating sanitary landfills, storage, and different kinds of collecting and transport vehicles. When choosing typical values, extreme caution should be taken because the densities of solid wastes vary significantly depending on geographic location, year's season, and amount of time in storage. Delivered municipal solid wastes.

It has been discovered that the typical value for compaction vehicles is around 300 kg/m3.

- Moisture Content

The moisture content is calculated by dividing the weight of water (wet weight less dry weight) by the total wet weight of the waste. Solid wastes become heavier with moisture, increasing collection and transportation costs. Additionally, because wet waste requires energy for the evaporation of water and the rising of the temperature of water vapour, the moisture content is a crucial element in deciding whether waste treatment by incineration is economically possible.

The typical range of moisture content is between 20 and 40 percent, which represents the extremes of wastes in a desert climate and in a place that receives a lot of precipitation during the wet season. But values higher than 40% are not out of the ordinary.

- Size

When recovering materials, especially mechanical methods like trommel screens and magnetic separators, it's crucial to consider the size and size distribution of the component elements in solid wastes.

Because it affects the design of mechanical separators and shredders, it is crucial to measure the size distribution of waste stream particles.

2. Chemical Characteristics

The chemical characteristics of waste are

- Lipids

This group of substances comprises fats, oils, and grease. Fats, cooking oils, and waste are the primary sources of lipids. High lipid waste is ideal for energy recovery since lipids have higher heating values—roughly 38,000 kJ/kg.

Lipids contribute to the liquid content during waste decomposition because they become liquid at temperatures just slightly higher than ambient.

Despite being biodegradable, lipids degrade very slowly because they are poorly soluble in water.

- Carbohydrates

Carbohydrates which include sugar and polymers of sugars (such as starch, cellulose, etc.) with the general formula (CH2O)x, are predominantly found in food and yard waste. Carbohydrates are easily biodegraded into substances like methane, carbon dioxide, and water. Decomposing carbs draws flies and rats; thus, they shouldn't be exposed for an extended time.

- Proteins

Proteins comprise an organic acid with an amine group (NH2) that has been replaced. Proteins are substances having the elements carbon, hydrogen, oxygen, and nitrogen.
They are primarily discovered in gardens and food waste. These compounds' partial breakdown may lead to the generation of amines with foul scents.

- Natural Fibres

Natural fibres, which include the biodegradable substances cellulose and lignin, are present in food waste, paper goods, and yard trash. They are appropriate for incineration since they are highly flammable solid waste with a high concentration of paper and wood materials.

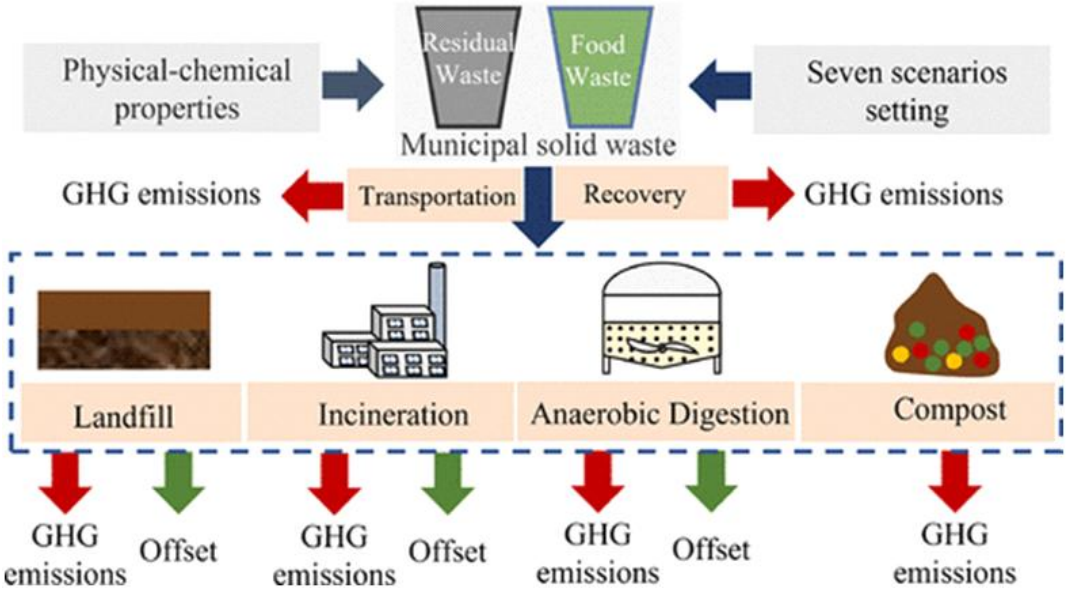

Figure 6.4: Characteristics of Solid Waste

Source: ACS Publications

6.5 Summary

- Any undesired material in our environment or from everyday products that is neither liquid nor gas is considered solid waste.
- Municipal solid waste (MSW) is a kind of waste that includes common goods discarded by the general public.
- Municipal solid waste categories eliminate industrial, agricultural, medical, and radioactive waste and sewage sludge. The municipality is in charge of collecting trash within a given area.
- There are two main categories in which solid waste can be categorised- Biodegradable and Non-Biodegradable.
- Hazardous waste in the industrial sector is mainly produced by the metals, chemical, paper, pesticide, dye, refining, and rubber goods industries. Direct exposure to toxic waste substances like mercury and cyanide can be fatal.
- Hospital waste is produced during the diagnosis, therapy, or immunisation of people or animals and the study, creation and testing of biological products.
- The accumulation of plastic objects (such as plastic bottles and other items) in the Earth's environment that has a detrimental effect on animals, wildlife habitats, and humans is called plastic waste, also known as plastic pollution.
- The moisture content is crucial in determining whether waste treatment by incineration is economically feasible because wet waste requires energy for water evaporation and for raising the temperature of water vapour.

6.6 Keywords

- **Solid Waste:** Any undesired material in our environment or from everyday products that is neither liquid nor gas is considered solid waste.
- **Solid Waste Management:** The term "solid waste management" refers to the entire procedure of gathering, handling, and getting rid of solid waste.
- **Residual Waste:** It describes garbage from residential sources that have yet to be moved or separated for processing.
- **Calorific value:** The quantity of heat energy created when the trash is burned.

6.7 Self-Assessment Questions

1. What is solid waste, and how is it different from liquid or gas waste?
2. What does municipal solid waste (MSW) include, and who is responsible for its collection?
3. How can solid waste be categorised into biodegradable and non-biodegradable?
4. What are some examples of industries that produce hazardous waste, and what are the potential dangers associated with exposure to such waste?
5. What is hospital waste, and what are its sources and characteristics?
6. How does the moisture content of waste affect the feasibility of waste treatment by incineration?
7. Write a note on the physical characteristics of solid waste.
8. Write a note on the chemical characteristics of solid waste.
9. Write a short note on Municipal Solid Waste.
10. Write a short note on Municipal Solid Waste and Industrial waste composition.

6.8 Case Study

The Brazilian city of Curitiba is an excellent case study in solid waste management. Curitiba adopted an innovative waste management system that prioritised recycling, waste reduction, and community involvement in the 1970s in response to rising garbage creation and a shortage of landfill space. Citizens were urged to sort their rubbish into various categories as part of the city's extensive recycling programme. Curitiba also established a network of parks and green spaces that acted as trash collection sites, fostering neighbourhood involvement and instruction. The city also invested in waste-to-energy facilities to turn non-recyclable waste into electricity. Due to these activities, Curitiba saw reduced landfill usage, a 70% recycling rate, and much better environmental conditions.

Questions:

1. How did Curitiba, Brazil, successfully implement a comprehensive recycling program as part of its solid waste management system, and what factors contributed to its high recycling rate of approximately 70%?

2. What were the innovative strategies and community engagement approaches employed by Curitiba to encourage waste reduction and segregation, including establishing green spaces and parks as waste collection points?
3. What were the environmental and social benefits observed in Curitiba due to its waste-to-energy plants, which converted non-recyclable waste into electricity, and how did this approach contribute to reducing landfill use and improving overall environmental conditions in the city?

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