VI Semester B Tech
Open Elective: Environment Engineering

Unit- I

Ecosystem

An ecosystem is a structural and functional unit of ecology where the living organisms interact with each other and the surrounding environment. In other words, an ecosystem is a chain of interactions between organisms and their environment. The term "Ecosystem" was first coined by A.G.Tansley, an English botanist, in 1935.

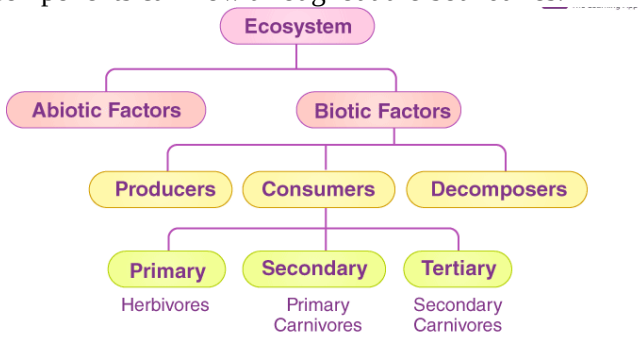
Structure of the Ecosystem

The structure of an ecosystem is characterized by the organization of both biotic and abiotic components. This includes the distribution of energy in **our environment**. It also includes the climatic conditions prevailing in that particular environment.

The structure of an ecosystem can be split into two main components, namely:

- Biotic Components
- Abiotic Components

The biotic and abiotic components are interrelated in an ecosystem. It is an open system where the energy and components can flow throughout the boundaries.



Biotic Components

Biotic components refer to all living components in an ecosystem. Based on nutrition, biotic components can be categorized into autotrophs, heterotrophs and saprotrophs (or decomposers).

- **Producers** include all autotrophs such as plants. They are called autotrophs as they can produce food through the process of photosynthesis. Consequently, all other organisms higher up on the food chain rely on producers for food.
- **Consumers** or heterotrophs are organisms that depend on other organisms for food. Consumers are further classified into primary consumers, secondary consumers and tertiary consumers.

  Primary consumers are always herbivores as they rely on producers for food.

  Secondary consumers depend on primary consumers for energy. They can either be carnivores or omnivores.

  Tertiary consumers are organisms that depend on secondary consumers for food. Tertiary consumers can also be carnivores or omnivores.

  Quaternary consumers are present in some food chains. These organisms prey on tertiary consumers for energy. Furthermore, they are usually at the top of a food chain as they have no natural predators.

  Decomposers include saprophytes such as fungi and bacteria. They directly thrive on the dead and decaying organic matter. Decomposers are essential for the ecosystem as they help in recycling nutrients to be reused by plants.

Abiotic Components

Abiotic components are the non-living component of an ecosystem. It includes air, water, soil, minerals, sunlight, temperature, nutrients, wind, altitude, turbidity, etc.

Functions of Ecosystem

The functions of the ecosystem are as follows:

1. It regulates the essential ecological processes, supports life systems and renders stability.
2. It is also responsible for the cycling of nutrients between biotic and abiotic components.
3. It maintains a balance among the various trophic levels in the ecosystem.
4. It cycles the minerals through the biosphere.
5. The abiotic components help in the synthesis of organic components that involve the exchange of energy.

So the functional units of an ecosystem or functional components that work together in an ecosystem are:

- **Productivity –** It refers to the rate of biomass production.
- **Energy flow –** It is the sequential process through which energy flows from one trophic level to another. The energy captured from the sun flows from producers to consumers and then to decomposers and finally back to the environment.
- **Decomposition –** It is the process of breakdown of dead organic material. The top-soil is the major site for decomposition.
- **Nutrient cycling –** In an ecosystem nutrients are consumed and recycled back in various forms for the utilization by various organisms.

Types of Ecosystem

An ecosystem can be as small as an oasis in a desert, or as big as an ocean, spanning thousands of miles. There are two types of ecosystem:

- Terrestrial Ecosystem
- Aquatic Ecosystem

Terrestrial Ecosystem

Terrestrial ecosystems are exclusively land-based ecosystems. There are different types of terrestrial ecosystems distributed around various geological zones. They are as follows:

1. Forest Ecosystem
2. Grassland Ecosystem
3. Tundra Ecosystem
4. Desert Ecosystem

Forest Ecosystem

A forest ecosystem consists of several plants, particularly trees, animals and microorganisms that live in coordination with the abiotic factors of the environment. Forests help in maintaining the temperature of the earth and are the major carbon sink.

Grassland Ecosystem

In a grassland ecosystem, the vegetation is dominated by grasses and herbs. Temperate grasslands and tropical or savanna grasslands are examples of grassland ecosystems.

Tundra Ecosystem

Tundra ecosystems are devoid of trees and are found in cold climates or where rainfall is scarce. These are covered with snow for most of the year. Tundra type of ecosystem is found in the Arctic or mountain tops.

Desert Ecosystem

Deserts are found throughout the world. These are regions with little rainfall and scarce vegetation. The days are hot, and the nights are cold.

Aquatic Ecosystem

Aquatic ecosystems

These are ecosystems present in a body of water. These can be further divided into two types, namely:

1. Freshwater Ecosystem
2. Marine Ecosystem

Freshwater Ecosystem

The freshwater ecosystem is an aquatic ecosystem that includes lakes, ponds, rivers, streams and wetlands. These have no salt content in contrast with the marine ecosystem.

Marine Ecosystem

The marine ecosystem includes seas and oceans. These have a more substantial salt content and greater biodiversity in comparison to the freshwater ecosystem.

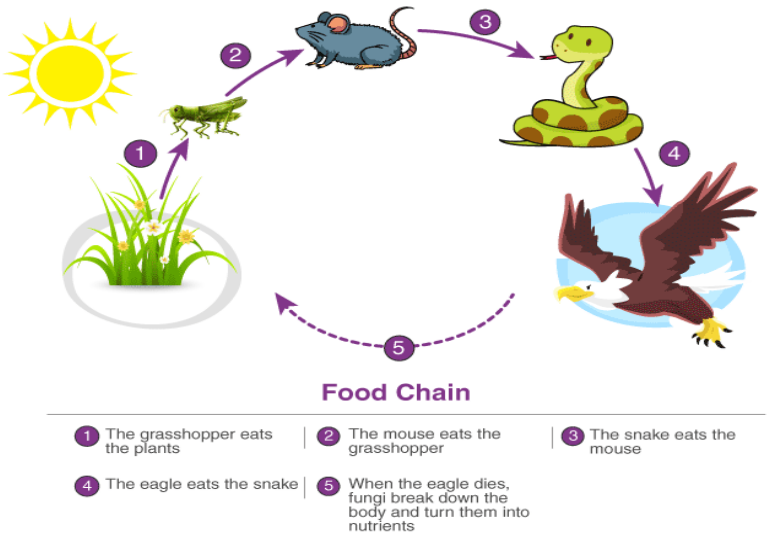
Important Ecological Concepts

1. Food Chain

The sun is the ultimate source of energy on earth. It provides the energy required for all plant life. The plants utilise this energy for the process of photosynthesis, which is used to synthesise their food.

During this biological process, light energy is converted into chemical energy and is passed on through successive trophic levels. The flow of energy from a producer, to a consumer and eventually, to an apex predator or a detritivore is called the food chain.

Dead and decaying matter, along with organic debris, is broken down into its constituents by scavengers. The reducers then absorb these constituents. After gaining the energy, the reducers liberate molecules to the environment, which can be utilized again by the producers.



2. Ecological Pyramids

An ecological pyramid is the graphical representation of the number, energy, and biomass of the successive trophic levels of an ecosystem. Charles Elton was the first ecologist to describe the ecological pyramid and its principals in 1927.

The biomass, number, and energy of organisms ranging from the producer level to the consumer level are represented in the form of a pyramid; hence, it is known as the ecological pyramid.

The base of the ecological pyramid comprises the producers, followed by primary and secondary consumers. The tertiary consumers hold the apex. In some food chains, the quaternary consumers are at the very apex of the food chain.

The producers generally outnumber the primary consumers and similarly, the primary consumers outnumber the secondary consumers. And lastly, apex predators also follow the same trend as the other consumers; wherein, their numbers are considerably lower than the secondary consumers.

For example, Grasshoppers feed on crops such as cotton and wheat, which are plentiful. These grasshoppers are then preyed upon by common mouse, which are comparatively less in number. The mice are preyed upon by snakes such as cobras. Snakes are ultimately preyed on by apex predators such as the brown snake eagle.

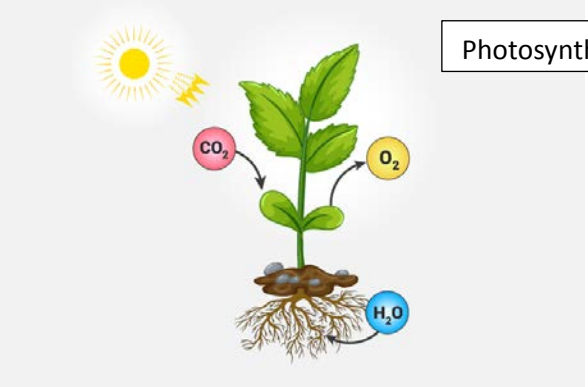
In essence:

3. Food Web

Food web is a network of interconnected food chains. It comprises all the food chains within a single ecosystem. It helps in understanding that plants lay the foundation of all the food chains. In a marine environment, phytoplankton forms the primary producer.

Energy Flow in Ecosystem

The energy flow in the ecosystem is one of the major factors that support the survival of such a great number of organisms. For almost all organisms on earth, the primary source of energy is solar energy. It is amusing to find that we receive less than 50 per cent of the sun's effective radiation on earth. When we say effective radiation, we mean the radiation, which can be used by plants to carry out photosynthesis.



Most of the sun's radiation that falls on the earth is usually reflected back into space by the earth's atmosphere. This effective radiation is termed as the Photosynthetically Active Radiation (PAR).

Law of Thermodynamics in the Ecosystem

The law of thermodynamics in the ecosystem explains the flow of energy at each trophic level. The first law states that energy is neither created, nor destroyed; it can only be converted from one form to another. This is true in energy flow in the ecosystem.

The second law states that there is loss of energy at each step of energy flow. This law also stands true in ecology as there is progressive decrease in energy at each trophic level.

Biodiversity Definition

"Biodiversity is the variation among living organisms from different sources including terrestrial, marine and desert ecosystems, and the ecological complexes of which they are a part."

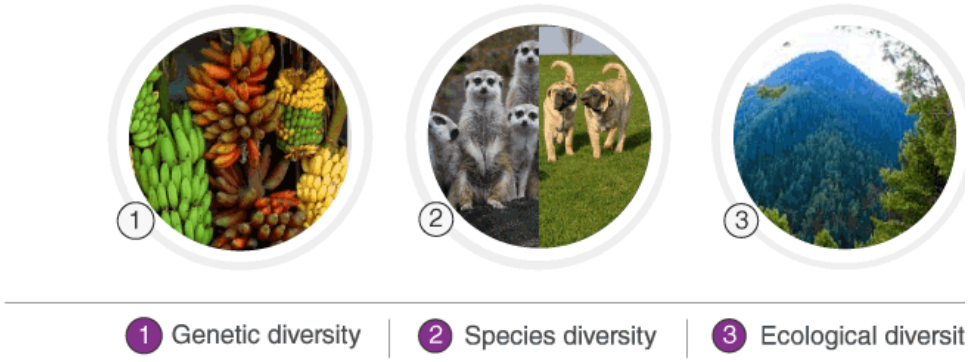
Biodiversity describes the richness and variety of life on earth. It is the most complex and important feature of our planet. Without biodiversity, life would not sustain. The term biodiversity was coined in 1985. It is important in natural as well as artificial ecosystems. It deals with nature's variety, the biosphere. It refers to variability among plants, animals and microorganism species. Biodiversity includes the number of different organisms and their relative frequencies in an ecosystem. It also reflects the organization of organisms at different levels. Biodiversity holds ecological and economic significance. It provides us with nourishment, housing, fuel, clothing and several other resources. It also extracts monetary benefits through tourism. Therefore, it is very important to have a good knowledge of biodiversity for a sustainable livelihood.

Types of Biodiversity

There are the following three different types of biodiversity:

- Genetic Biodiversity
- Species Biodiversity
- Ecological Biodiversity

BIODIVERSITY AND ITS TYPES



Species diversity

Species diversity refers to the variety of different types of species found in a particular area. It is the biodiversity at the most basic level. It includes all the species ranging from plants to different microorganisms. No two individuals of the same species are exactly similar. For example, humans show a lot of diversity among themselves.

Genetic diversity

It refers to the variations among the genetic resources of the organisms. Every individual of a particular species differs from each other in their genetic constitution. That is why every human looks different from each other. Similarly, there are different varieties in the same species of rice, wheat, maize, barley, etc.

Ecological diversity

An ecosystem is a collection of living and non-living organisms and their interaction with each other. Ecological biodiversity refers to the variations in the plant and animal species living together and connected by food chains and food webs. It is the diversity observed among the different ecosystems in a region. Diversity in different ecosystems like deserts, rainforests, mangroves, etc., includes ecological diversity.

Importance of Biodiversity

Biodiversity and its maintenance are very important for sustaining life on earth. A few of the reasons explaining the importance of biodiversity are:

Ecological Stability

Every species has a specific role in an ecosystem. They capture and store energy and also produce and decompose organic matter. The ecosystem supports the services without which humans cannot survive. A diverse ecosystem is more productive and can withstand environmental stress.

Economic Importance

Biodiversity is a reservoir of resources for the manufacture of food, cosmetic products and pharmaceuticals.

Crops livestock, fishery, and forests are a rich sources of food.

Wild plants such as Cinchona and Foxglove plant are used for medicinal purposes.

Wood, fibres, perfumes, lubricants, rubber, resins, poison and cork are all derived from different plant species.

The national parks and sanctuaries are a source of tourism. They are a source of beauty and joy for many people.

Ethical Importance

All species have a right to exist. Humans should not cause their voluntary extinction. Biodiversity preserves different cultures and spiritual heritage. Therefore, it is very important to conserve biodiversity.

Biodiversity in India

India is one of the most diverse nations in the world. It ranks ninth in terms of plant species richness. Four of the world's 36 biodiversity hotspots are found in India. It is the origin of important crop species such as pigeon pea, eggplant, cucumber, cotton and sesame. India is also a centre of various domesticated species such as millets, cereals, legumes, vegetables, medicinal and aromatic crops, etc.
India is equally diverse in its faunal wealth. There are about 91000 animal species found here.
However, diversity is depleting at a drastic rate and various programmes.
being launched to conserve nature.

Biodiversity loss refers to the reduction of biodiversity due to displacement or extinction of species. The loss of a particular individual species may seem unimportant to some, especially if it is not a charismatic species like the Bengal tiger or the bottlenose dolphin. However, biologists estimate that species extinctions are currently many times higher the normal, or background, rate seen previously in Earth's history. This translates to the loss of tens of thousands of species within our lifetimes. This is likely to have dramatic effects on human welfare through the collapse of ecosystems. Loss of biodiversity may have reverberating consequences on ecosystems because of the complex interrelations among species. For example, the extinction of one species may cause the extinction of another. To measure biodiversity loss, scientists assess which species are at risk of extinction as well as survey ecosystem decline.
The core threat to biodiversity on the planet is the combination of human population growth and the resources used by that population. The human population requires resources to survive and grow, and many of those resources are being removed unsustainably from the environment. The five main threats to biodiversity are habitat loss, pollution, overexploitation, invasive species, and climate change. Increased mobility and trade has resulted in the introduction of invasive species while the other threats are direct results of human population growth and resource use.

Extinction

- Extinction is the global loss of a species. Five mass extinctions have occurred in geological history, and extinction rates were particular high during these events. Earth is currently experiencing a sixth mass extinction, which is driven by human activities. When mass extinctions are not occurring, extinction still occurs at a low rate, the background extinction rate. The local elimination of a species (extirpation) is also of conservation concern.

Measures of Biodiversity Loss

A common means of assessing biodiversity loss involves classifying species based on extinction risk. The Red List includes nine such categories. The species at greatest risk of extinction are called critically endangered, followed by endangered, vulnerable, and near threatened species. Biodiversity can also be gauged at the ecosystem level, both in terms of area and ecosystem diversity.

Habitat Loss

Habitat loss includes habitat destruction, altering the physical environment such that a species can no longer live there, and habitat fragmentation, which involves dividing a habitat into discontinuous patches.

Overexploitation

Overexploitation involves removing organisms at a faster rate than they can be replenished. Examples include the poaching of elephants, unsustainable hunting for bush meat, overfishing, and overcollection of slow-growing plants and fungi.

Pollution

Pollution is the release of harmful chemicals or other materials into the environment. Some types of air pollution results in acid deposition and climate change. Nutrient pollution of water bodies due to fertilizer overuse results in eutrophication.

Invasive Species

Invasive species are those occurring outside of their historical distribution that cause ecological and/or economic harm. Invasive species can overpredate or outcompete native species, sometimes causing their extinction or extirpation. Examples of invasive species include the Asian carp, zebra mussels, Bd (which causes a fungal disease in amphibians), purple loosestrife, and the European

starling. Biological control employs other organisms to control invasive species and has had successes and fa

- Climate Change

  The release of greenhouse gases, like carbon dioxide and methane, when burning fossil fuels for energy causes climate change. Not only does climate change involve an increase in average global temperature, but it also results in unpredictable weather patterns. Climate change threatens biodiversity through a variety of mechanisms and can cause species range shifts, mismatched biotic interactions, sea level rise, and ocean acidification.

Biodiversity Conservation

It is believed that an area with higher species abundance has a more stable environment compared to an area with lower species abundance. We can further claim the necessity of biodiversity by considering our degree of dependency on the environment. We depend directly on various species of plants for our various needs. Similarly, we depend on various species of animals and microbes for different reasons.

Biodiversity is being lost due to the loss of habitat, over-exploitation of resources, climatic changes, pollution, invasive exotic species, diseases, hunting, etc. Since it provides us with several economic and ethical benefits and adds aesthetic value, it is very important to conserve biodiversity.

Biodiversity conservation is the protection and management of biodiversity to obtain resources for sustainable development.

Biodiversity conservation has three main objectives:

- To preserve the diversity of species.
- Sustainable utilization of species and ecosystem.
- To maintain life-supporting systems and essential ecological processes.

Let us have a detailed look at biodiversity and its conservation notes to explore the strategies and concepts of biodiversity conservation.

Biodiversity and its Conservation Methods

Biodiversity refers to the variability of life on earth. It can be conserved in the following ways:

- In-situ Conservation
- Ex-situ Conservation

In-situ Conservation

In-situ conservation of biodiversity is the conservation of species within their natural habitat. In this method, the natural ecosystem is maintained and protected.

The in-situ conservation has several advantages. Following are the important advantages of in-situ conservation:

1. It is a cost-effective and convenient method of conserving biodiversity.
2. A large number of living organisms can be conserved simultaneously.
3. Since the organisms are in a natural ecosystem, they can evolve better and can easily adjust to different environmental conditions.

Certain protected areas where in-situ conservation takes place include national parks, wildlife sanctuaries and biosphere reserves.

National Parks

These are small reserves maintained by the government. Its boundaries are well demarcated and human activities such as grazing, forestry, habitat and cultivation are prohibited. For eg., Kanha National Park, and Bandipur National Park.

Wildlife Sanctuaries

These are the regions where only wild animals are found. Human activities such as timber harvesting, cultivation, collection of woods and other forest products are allowed here as long as they do not interfere with the conservation project. Also, tourists visit these places for recreation.

Biosphere Reserves

Biosphere reserves are multi-purpose protected areas where the wildlife, traditional lifestyle of the inhabitants and domesticated plants and animals are protected. Tourist and research activities are permitted here.

Ex-situ Conservation

Ex-situ conservation of biodiversity involves the breeding and maintenance of endangered species in artificial ecosystems such as zoos, nurseries, botanical gardens, gene banks, etc. There is less competition for food, water and space among the organisms.

Ex-situ conservation has the following advantages:

1. The animals are provided with a longer time and breeding activity.
2. The species bred in captivity can be reintroduced in the wild.
3. Genetic techniques can be used for the preservation of endangered species.

Strategies for Biodiversity Conservation

Following are the important strategies for biodiversity conservation:

1. All the varieties of food, timber plants, livestock, microbes and agricultural animals should be conserved.
2. All the economically important organisms should be identified and conserved.
3. Unique ecosystems should be preserved first.
4. The resources should be utilized efficiently.
5. Poaching and hunting of wild animals should be prevented.
6. The reserves and protected areas should be developed carefully.
7. The levels of pollutants should be reduced in the environment.
8. Deforestation should be strictly prohibited.
9. Environmental laws should be followed strictly.
10. The useful and endangered species of plants and animals should be conserved in their nature as well as artificial habitats.
11. Public awareness should be created regarding biodiversity conservation and its importance.

Natural Resources and Associated Problems

Natural resources are very useful to man. They contribute to industrial and economic development and promote human welfare. But there are several problems associated with the exploitation and use of natural resource as follows.

1. Natural resources are not unlimited. They are finite or limited. So, unless they must be properly exploited and wisely used to make them available for the future generation too.

2. Most of the natural resources, particularly minerals and fossil fuels like coal, petroleum and natural gas are non-renewable. So, over-exploitation and over utilization of these resources will leads to shortage or scarcity in future.

3. Over-exploitation of natural resources, such as forests, wildlife, marine life, etc. will leads to ecological imbalance.

4 All natural resources are not easily accessible to man for exploitation. So, there arises the problem of efficient exploitation of natural resources.

5. Huge cost is involved in the exploitation of natural resources.

Eg: Mining for the exploitation of minerals, constructions of dams for power generation, irrigation are costly.

6. Over-exploitation of forests, reckless felling of trees, will lead to deforestation.

7. Deforestation, resulting from over-exploitation of forests, results in loss of natural habitats for wildlife.

8. Deforestation and over or unwise use of land resources may lead to desertification.

9. Soil erosion is a serious problem resulting from over-exploitation of forests, mining, improper land use, etc.

10. Over-exploitation of marine life will result in loss of certain spices of fishes and other marine life.

11. Pollution is a serious problem associated with over-exploitation and over-utilization of natural resources.

12. Over-exploitation and over-utilization of natural resources like forests, minerals, fossil fuels, lands, etc. is responsible for air pollution, noise pollution, etc.

13. Hazards, such as landslides, floods, etc., are associated with exploitation of natural resources.

14. Exploitation of rivers by constructing large dams causes problems, such as loss of Biodiversity, displacement of tribal people, etc.

Natural resources are of three types:

Type 1-Based on continual supply (Renewable and non-renewable) :

There are some resources which can be and cannot be exhausted. Thus, depending upon the availability of the resources a resource can be renewable (inexhaustible) and non-renewable (exhaustible) or cyclic.

The resources that can be replenished rapidly through natural cycle are called renewable resources. Examples are solar radiation, wind energy, water energy, biomass energy (solar energy stored in wood), food and other agricultural products forests, wildlife and grasslands etc.

The resources, which can be replenished, slowly or even not replenished at all through natural processes are called non-renewable resources. Non-renewable resources are further divided into two categories. These are:

(a) Recyclable:

These resources can be collected after they are used and can be recycled. Such resources are mainly non-energy resources, which occur on the earth's crust, Examples are one it aluminum and other metals.

(b) Non-recyclable:

These resources cannot be recycled in any way for example mineral energy resources such as fossil as fuels (Coal, oil and natural gas and natural energy).

Type 2-Based on origin (Biotic and Abiotic) :

Natural resources may be organic (biotic) or inorganic (abiotic). Biotic resources are obtained from the biosphere e.g. forest, and forest products, crops and animal, fish, coal and mineral oil. Abiotic resources are obtained from land, water, and minerals like iron, copper lead and gold.

There are many problems associated with natural resources:

Forest resources and associated problems

1. Use and over-exploitation.
2. Deforestation.
3. Timber extraction.
4. Mining and its effects on forest.
5. Dams and their effects on forests and tribal people.

Water resources and associated problems

1. Use and overutilization of water.
2. Floods, droughts etc.
3. Conflicts over water.
4. Dams and problems.

Mineral resource and associated problems

1. Use and exploitation.
2. Environmental effects of extracting and using minerals.

Food resources and associated problems

1. World food problems.
2. Changes caused by agriculture and over grazing.
3. Effects of modern agriculture.
4. Fertilizer-pesticide problems.
5. Water logging and salinity.

Energy resources and associated problems

1. Growing energy needs.

Land resources and associated problems

1. Land degradation.
2. Man-induced landslides.
3. Soil erosion and desertification.

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Role and responsibility of engineer in environmental protection

Environmental engineers are responsible for developing and implementing solutions to environmental problems. They use scientific and engineering principles to protect the environment and human health.

Responsibilities

- **Design systems**: Create systems to protect the environment, such as water reclamation and air pollution control systems
- **Analyse data**: Collect, analyse, and manage environmental data from site assessments, monitoring, and reports
- **Evaluate impact**: Assess the environmental impact of projects, hazards, and commercial operations
- **Make recommendations**: Provide recommendations for remediation, recycling, waste disposal, and more
- **Develop plans**: Create plans to protect and restore the environment
- **Monitor progress**: Monitor the progress of environmental improvement programs
- **Ensure compliance**: Ensure compliance with environmental regulations and industry standards
- **Communicate**: Communicate with stakeholders, government agencies, and corporations about environmental issues
- **Research**: Research alternative energy sources and the effects of global warming, acid rain, and other environmental issues
- **Advise**: Advise on environmental issues, such as procedures for cleaning up contaminated sites

  Environmental engineers work in a variety of settings, including industrial facilities, municipal programs, and construction sites.
- **Risk assessment**: Identify potential hazards and develop strategies to mitigate them
- **Safety inspections**: Regularly inspect workplaces and machinery to identify potential hazards
- **Safety training**: Provide training to employees on how to stay safe
- **Incident investigation**: Investigate incidents to determine the cause
- **Safety policies and procedures**: Develop and implement safety policies and procedures
- **Safety audits**: Conduct safety audits to ensure compliance with safety standards
- **Emergency preparedness**: Prepare for emergencies and ensure that employees are able to respond appropriately
- **Regulatory compliance**: Ensure that companies comply with safety laws and regulations
- **Environmental impact assessment**: Consider the environmental impact of designs, such as air and water quality, wildlife, and ecosystems

Fire hazards, prevention and precautions

Fire hazards are conditions that increase the likelihood of a fire. Fire prevention and safety measures include fire extinguishers, fire alarms, and emergency plans.

Fire prevention and safety measures

- **Fire extinguishers**

  Keep a fire extinguisher in your kitchen and know how to use it.
- **Fire alarms**

  Install smoke alarms on every level of your property and test them monthly.
- **Fire safety plan**

  Document potential hazards and safety protocols to follow in case of a fire
- **Emergency plan**

  Have an emergency plan in place so people know what to do in the event of a fire.
- **Fire hazard assessment**

  Have a professional assess your facility for fire hazards and make recommendations for improvement.
- **Control ignition sources**

  Control open flames, heaters, cooking equipment, and other hazards that could cause a fire.

  Fire safety precautions
  - Don't leave cooking unattended, especially when using high heat.
  - Keep flammable materials away from the stove.

- Be careful when frying with oil.
- Maintain fire safety equipment.

Industrial hazard prevention and protection

Industrial hazard prevention and protection involves identifying and controlling potential hazards in the workplace. This can include developing procedures, using safety equipment, and communicating hazards to workers.

Hazard identification

- **Identify hazards**: Recognize potential hazards, such as chemical exposure, falls, or electrical hazards
- **Communicate hazards**: Inform workers about the hazards they may face and how to stay safe

Hazard control

- **Eliminate hazards**: Remove hazards from the workplace
- **Substitute hazards**: Replace hazards with less risky alternatives
- **Isolate hazards**: Separate hazards from people and other hazards
- **Use engineering controls**: Use machinery and equipment to control hazards
- **Use administrative controls**: Create policies and procedures to control hazards
- **Use personal protective equipment (PPE)**: Wear safety glasses, gloves, and other protective gear

Hazard prevention programs

- **Create a hazard prevention program**: Develop a workplace-specific program to prevent injuries and diseases
- **Prepare for emergencies**: Develop plans and procedures to respond to emergencies

Population growth aspects and importance and effects on environment

Population growth can have many negative effects on the environment, including climate change, biodiversity loss, and pollution.

Effects of population growth on the environment

- **Climate change**: More people mean more carbon emissions, especially if energy comes from fossil fuels.
- **Biodiversity loss**: Population growth increases human activity, which can lead to the decline or disappearance of living organisms.
- **Pollution**: Population growth can lead to more pollution.
- **Deforestation**: As the population grows, the demand for land increases, which can lead to deforestation.
- **Habitat destruction**: Population growth can lead to widespread habitat destruction.
- **Rising sea levels**: Population growth can contribute to rising sea levels.
- **Over-harvesting**: Population growth can contribute to over-harvesting.

Factors that can exacerbate the effects of population growth Consumption habits, Technological developments, Patterns of social organization, and Patterns of resource management

Human health and Human rights

Health and human rights are related in several ways, including:

- **Right to health**
  The right to health is a fundamental human right that is enshrined in several human rights treaties. It includes the right to access, availability, quality, and acceptability of health care.
- **Non-discrimination**
  The right to health must be enjoyed without discrimination based on race, age, ethnicity, or any other factor.
- **Human rights-based approach**
  The human rights-based approach (HRBA) to sustainable development aims to ensure that all people can claim their human rights.
- **Legal guarantees**
  Legal guarantees and enforcement mechanisms are central to the right to health.
- **Mental health**

Ensuring mental health as a human right means advocating for policies that protect individuals with mental health conditions

- **Digital technologies**
  The adoption of digital technologies for health must align with the right to health.
- **Society's responsibilities**
  Society has a responsibility to ensure equitable and universal access to appropriate health care.
  Health and Human Rights is also the name of a peer-reviewed public health journal published by Harvard University Press. It covers research on the conceptual foundations of human rights and social justice in relation to health

Concept of carbon credits

Carbon credits, also known as carbon offsets, are a way to fund climate action by reducing or removing carbon emissions from the atmosphere. They are tradable instruments that represent a claim to reduced or removed greenhouse gas emissions (GHG).
Here are some key concepts about carbon credits:

- **Generation**
  Carbon credits are created by projects that reduce or remove GHG emissions, such as reforestation or renewable energy projects.
- **Certification**
  Carbon credits must be certified by an independent body or government to ensure they meet environmental integrity principles.
- **Trading**
  Carbon credits are bought, sold, and exchanged in carbon markets.
- **Use**
  The buyer of a carbon credit can use it to count towards a climate change mitigation goal.
- **Co-benefits**
  Some carbon credit projects can also provide other benefits, such as reducing health problems, improving water quality, and creating jobs.
- **Cap-and-trade**
  In a cap-and-trade market, emitters must trade credits to stay within a government-set limit on the amount of GHGs that can be released into the atmosphere.
  The United Nations' Intergovernmental Panel on Climate Change (IPCC) developed the concept of carbon credits in the Kyoto Protocol in 1997.

Environment Protection Law - 1986

Aims and Objectives of the Environment Protection Act

The chief aims and objectives of the Environment Protection Act, 1986 are listed below.

1. Implementing the decisions made at the United Nations Conference on Human Environment held in Stockholm.
2. Creation of a government authority to regulate industry that can issue direct orders including closure orders.
3. Coordinating activities of different agencies that are operating under the existing laws.
4. Enacting regular laws for the protection of the environment.
5. Imposing punishments and penalties on those who endanger the environment, safety and health. For each failure or contravention, the punishment includes a prison term of up to five years or a fine of up to Rs. 1 lakh, or both. This can also be extended for up to seven years in cases.
6. Engaging in the sustainable development of the environment.
7. Attaining protection of the right to life under Article 21 of the Constitution.

Main Provisions of Environment Protection Act

The EPA empowers the Centre to "take all such measures as it deems necessary" in the domain of environmental protection.

- Under the law, it can coordinate and execute nationwide programmes and plans to further environmental protection.
- It can mandate environmental quality standards, particularly those concerning the emission or discharge of environmental pollutants.
- This law can impose restrictions on the location of industries.
- The law gives the government the power of entry for examination, testing of equipment and other purposes and power to analyse the sample of air, water, soil or any other substance from any place.
- The EPA explicitly bars the discharge of environmental pollutants in excess of prescribed regulatory standards.
- There is also in place a specific provision for handling hazardous substances, which is prohibited unless in compliance with regulatory requirements.
- The Act empowers any person, apart from authorised government officers, to file a complaint in a court regarding any contravention of the provisions of the Act.

Wildlife Protection Act, 1972

This Act provides for the protection of the country's wild animals, birds, and plant species, in order to ensure environmental and ecological security. Among other things, the Act lays down restrictions on hunting many animal species. The Act was last amended in the year 2006. An Amendment bill was introduced in the Rajya Sabha in 2013 and referred to a Standing Committee, but it was withdrawn in 2015.

Salient Features of Wildlife Protection Act

This Act provides for the protection of a listed species of animals, birds, and plants, and also for the establishment of a network of ecologically-important protected areas in the country.

- The Act provides for the formation of wildlife advisory boards, wildlife wardens, specifies their powers and duties, etc.
- For the first time, a comprehensive list of the endangered wildlife of the country was prepared.
- The Act **prohibited the hunting of endangered species**.
- Scheduled animals are prohibited from being traded as per the Act's provisions.
- The Act provides for licenses for the sale, transfer, and possession of some wildlife species.
- It provides for the establishment of wildlife sanctuaries, national parks, etc.
- Its provisions paved the way for the formation of the **Central Zoo Authority**. This is the central body responsible for the oversight of zoos in India. It was established in 1992.

Forest Conservation Act 1980

The Parliament has enacted the Forest (Conservation) Act, 1980, to check further deforestation and conserve forests and to provide for matters connected therewith or ancillary or incidental thereto. This Act has five Sections which deal with conservation of forests.

Objectives:
The Act was enacted with the twin objectives under Section 2 of restricting the use of forest land for non-forest purposes, and preventing the de-reservation of forests that have been reserved under the Indian Forest Act, 1927.

The salient features of the Act are as follows:

1. The act places restrictions on the power of the State Government concerning preservation of forests or use of forest land for non-forest purposes.
2. Section 2 of the Act provides that the State Government shall not make amendments except with the prior approval of the Central Government or any order directing thereon:

Question Bank

1. What is the ecosystem? How they are important to the life on earth? Explain
2. What are the different types of ecosystems? Discuss at length
3. What are the functional components of an ecosystem? Describe in detail
4. Which ecosystem do we live in? Why? Explain
5. What is the structure of the ecosystem? Describe
6. Which is the largest ecosystem in the world? How? Explain
7. What is the major function of an ecosystem? Enumerate and explain
8. What makes a good ecosystem? Describe the characteristics of good ecosystem
9. What all include the non-living things in an ecosystem?
10. What do you understand by the energy flow? Describe in detail
11. Why is the energy flow in ecosystem important? Explain
12. What is the primary or main source of energy in the ecosystem?
13. What is biodiversity? Explain
14. What are the types of biodiversity?
15. What is the role of biodiversity in maintaining environmental balance? Explain
16. What is the importance of biodiversity?
17. Why is it important to conserve biodiversity?
18. What are the different methods of conserving biodiversity? Describe in detail
19. Enlist and describe the causes of biodiversity loss.
20. What are the natural resources? Enlist their types
21. What problems are associated with natural resources? Describe
22. What problems are associated with Forest, Mine & water as natural resources?

Unit – II

Water Resources

Water is one of the most vital sources for all living organisms. Although water is a renewable resource, scarcity of quality water is still a big issue in many parts of the world. We need water for various purposes such as to grow food, keep clean, generate electricity, control fire, and most importantly to stay alive.

Types of Water Resources

Saltwater Resources:

- The planet's atmosphere is covered in saltwater. However, when it relates to potable water sources, saltwater is actually ineffective. Desalination plants, though they do operate, are in short supply due to the high energy costs associated with the operation.
- Apart from spectacular ocean views, there have been saltwater opportunities through which humans gain profit. Saltwater fish is indeed a staple of many people's diets around the world. In addition, tidal waters have been used to generate hydroelectric power.

Groundwater Resources:

- Of all the freshwater resources, groundwater in the water natural resources is perhaps the most abundant. Part of the water that filters down into the soil via layers of dirt, clay, and rock stacks to the uppermost layers, providing water to the plants.
- This water is in the vadose region, which means it is unsaturated. Instead of water, almost all of the pores in the vadose zone are filled with air.
- Inputs, outputs, and storage are the same for groundwater as they are for surface water. The crucial distinction is that, due to the slow turnover rate, groundwater storage is typically much greater (in volume) than surface water storage in comparison to inputs.
- Because of this distinction, humans may use groundwater in an unsustainable manner over an extended period of time without suffering serious repercussions. Nonetheless, the average rate of drainage above a groundwater source is the upper limit for average groundwater use during the longer run.

Surface Water Resources:

- The water in lakes and rivers is known as surface water. Potable water, recreation, industry, agriculture, transportation, livestock, and hydroelectric energy are all uses for this water.
- Groundwater natural resources provide over 63 percent of the municipal water supply. Irrigation relies on surface water for 58 percent of all its water supply. Irrigation relies on groundwater for 58 percent of its water system.
- Surface water systems have nearly 98 percent of the water used by industry. As a result, maintaining and improving the surface water quality is critical. Watershed entities track stream flow and groundwater management on a regular basis.
- Flooding and drought conditions are predicted by monitoring stream flow. Since surface water provides most of the water used within the United States, water resources information and management are important. It is a chemical, biological, and physical test that determines how acceptable the water is.
- Electrical conductivity, temperature, pH, dissolved oxygen levels, phosphorus levels, bacteria levels, and nitrogen levels are evaluated as indicators of water quality.

Though earth is called the water planet as it is occupied by 75 percent of water, this water cannot be used for domestic purposes. Ocean water is saline in nature and is not fit for human consumption. Freshwater is just around 2.7 percent of the total water on the earth. Issues such as global warming and perpetuating water pollution have made a considerable amount of impact on making freshwater unfit for human consumption.

Uses of Freshwater

Water resources are used in various fields such as agricultural, industrial, domestic, recreational, and environmental activities. Most of the uses require fresh water. However, around 97 percent of the water on the earth is saltwater and only three percent is freshwater. About two-thirds of the available freshwater is frozen in glaciers and polar ice caps. The remaining freshwater is found underground and a negligible portion of it is present on the ground or in the air.

Classification of waters

Water can occur in three states: solid (ice), liquid or gas (vapor).

- Solid water – ice is frozen water. When water freezes, its molecules move farther apart, making ice less dense than water. ...
- Liquid water is wet and fluid. ...
- Water as a gas – vapor is always present in the air around us.

Types of water:

Surface water
Groundwater
Wastewater
Strom water

Composition of water:

Water is formed when two hydrogen atoms are combined with one oxygen atom, hence, it has a chemical formula H2O H 2 O . **Because it is composed of two or more atoms**, it is a compound. Water is classified as a pure substance (compound).

Origin of water:

Liquid water, which is necessary for life as we know it, continues to exist on Earth's surface. But, the origin of Earth's water remains unknown.

It was long thought that Earth's water did not originate from the planet's region of the protoplanetary disk. Instead, it was hypothesized water and other volatiles must have been delivered to Earth from the outer Solar System later in its history.

Recent research suggests that the Earth's water may have come from materials that were present in the inner solar system at the time the planet formed.

Enstatite chondrite (EC) meteorites have similar isotopic composition to terrestrial rocks and may represent the material that formed Earth. Scientists determined that an enstatite chondrite contains adequate hydrogen to deliver at least three times the amount of water in the Earth's oceans, and most likely significantly more.

Physically, domestic wastewater is usually characterized by a grey color, musty odor and has a solids content of about 0.1%. The solid material is a mixture of faeces, food particles, toilet paper, grease, oil, soap, salts, metals, detergents, sand and grit. The solids can be suspended (about 30%) as well as dissolved (about 70%). Dissolved solids can be precipitated by chemical and biological processes. From a physical point of view, the suspended solids can lead to the development of sludge deposits and anaerobic conditions when discharged into the receiving Environment.

Characteristics of domestic water

Drinking water can come from any source and is meant for human consumption for drinking and cooking. It covers all water for human consumption, whether treated or untreated. The Bureau of Indian Requirements established IS 10500: 2012 as the quality standards for drinking water in India.

Physical characteristics of drinking water

1: Turbidity

A turbidity rod or a turbidity meter with optical observations is used to measure turbidity, which is expressed as the quantity of suspended particles in mg/l or parts per million (ppm).

The use of a turbidity rod to measure turbidity in the field is common. To test the turbidity of water in the laboratory, many turbidity meters are used, the most frequent of which are the Jackson and Baylis turbidity meters. The maximum turbidity allowed in drinking water is 5 to 10 parts per million.

2: Temperature

The temperature isn't utilized to determine whether or not water is drinkable. Temperature, on the other hand, is a crucial physical component that impacts water quality in natural water systems such as lakes and rivers. A temperature of 10°C is regarded acceptable for drinkable water, whereas a temperature of 25°C is deemed objectionable.

3: Color

Colorless water indicates purity; colorful water indicates contamination. Color in water gives it an unappealing aspect.

The color generated by one milligram of platinum cobalt in one liter of distilled water is the unit of color on the cobalt scale. In the laboratory, a slide with conventional numbers is kept available. The number on the cobalt scale for public water supply should not exceed 20 and better be less than 10.

4: Taste and Odor

Odor intensity, which is connected to the threshold odor or threshold odor number, is used to describe the amount of taste or odor present in a certain sample of water. The water in public sources should be typically odor-free, i.e. the threshold number should be 1 and never exceed 3.

Chemical characteristics of drinking water

1: Total solids

The quantities of dissolved and suspended matter in water are assessed separately in this test, then put together to produce the total quantity of solids in water. The maximum allowable level of total solids is 1500 mg/lt, with 500 mg/lt being the highest desired level.

2: pH value of water

Permissible pH value for public supplies may range between 6.6 - 8.4. The lower value of pH may cause incrustation, sediment deposits, and difficulty in chlorination.

3: Chloride content

The chloride concentration of water intended for consumption shall not exceed 250 parts per million.

4: Dissolved oxygen or DO

The amount of free, non-compound oxygen contained in water or other liquids is referred to as DO. Because of its impact on the creatures that live in a body of water, it is an important metric in determining water quality. It is possible to calculate the amount of oxygen ingested. This level should be around 5 to 10 ppm for drinkable water.

5: Hardness

The water is quite soft, with a hardness of around 5, and excessively soft water is tasteless. The hardness should preferably be more than 5 but less than 8 for potable water.

Biological characteristics of drinking water

1: Indicator organisms

Coliform bacteria are a kind of bacterium that is used as a biological indicator of water and pollution. Escherichia coli, or E. coli, is a kind of coliform found in residential sewage.

2: Bacteria

Bacteria are single-celled creatures with no distinct nucleus and no green material to assist in the production of their own sustenance. For good potable water, total count of bacteria should be between 0 to 100.

Wastewater

Wastewater is defined as any water that has been harmed by people in terms of quality. It is made up of liquid and solid waste that is released from homes, agricultural facilities businesses, manufacturing plants, and land. A wide spectrum of pollutants can be found in wastewater at varied quantities.

Characteristics of Wastewater

Wastewater characteristics are divided into three categories: physical, chemical, and biological. Here's a basic rundown of each one:

Physical

Color, temperature, odor, and turbidity are all physical features of wastewater. When freshwater is exposed to the environment, it progressively becomes yellow until finally turning into black. In addition, there can be a lot of turbidity in the effluent. This is due to suspended particles in wastewater, which gives it a hazy appearance.

When it comes to smell, wastewater has a strong odor. Because there is more biological activity in wastewater, it has a greater temperature. This is important for you to grasp since a thorough understanding of the physical components may assist you in selecting the best treatment facility.

Chemical

Some of the components that determine the chemical characteristics of wastewater include nitrogen, chlorides, phosphorus, sulphates, heavy metals, pH, and so on. A detailed investigation of the physical and chemical properties is carried out to find the suitable sewage treatment facility in India. You may use the information to find the wastewater treatment facility that best meets your needs.

Biological

The biochemical oxygen demand (BOD), nitrogenous oxygen demand (NOD), and the presence and concentration of microbial life in wastewater make up the biological aspect of wastewater. Bacteria, fungus, protozoa, viruses, rotifers, algae, and nematodes make up the microbiological life in wastewater.

Biological oxygen demand (BOD)

The quantity of oxygen required by bacteria during the degradation of organic material is known as the **Biological Oxygen Demand** (BOD). Natural waterways should have a **BOD** of 5 mg/L or less to be considered unpolluted. **BOD** values in raw sewage can range from 150 to 300 mg/L. A low BOD implies that the water is of excellent quality, whereas a high BOD shows that the water is contaminated.

Chemical oxygen demand (COD) and **biological oxygen demand** (BOD) are both used to calculate the quantity of organic molecules in water. COD readings are usually higher than BOD values.

Water Pollution (Prevention) Act-1974

The Water (Prevention and Control of Pollution) Act was enacted in 1974 to provide for the prevention and control of water pollution, and for the maintaining or restoring of wholesomeness of water in the country. The Act was amended in 1988. The Act was last amended in 2003.

The main aim of this act is as follows:

- To prevent and regulate water contamination is the major goal of this act
- To retain the wholesomeness" of water, that is, to keep its properties so that it can be consumed and used by living creatures
- To establish State Boards for pollution prevention and control, which was superseded by the Air Act of 1981
- To give the Boards more authority over pollution prevention and control. To impose penalties for violating the requirements of this Act's rules
- To establish state-run water testing labs and develop protocols for them.

Indian Standards of Drinking water – IS 10500 – 1983 (Revised in 2012)

Sl. No.	Substance or Characteristics	Requirement Desirable Limit	Undesirable Effect Outside the Desirable Limit	Desirable/ Essential	Remarks
1.	Color, Hazen Units, Max.	--	Above 10	Essential	May be extended to 50 only if toxic

Sl. No.	Substance or Characteristics	Requirement Desirable Limit	Undesirable Effect Outside the Desirable Limit	Desirable/ Essential	Remarks
					substances are not suspected in absence of alternative sources.
2.	Odor	Objectionable	--	Essential	a)Test cold and when heated. b)Test at severaldilution s.
3.	Taste	Agreeable	--	Essential	Test to be conducted only after safety has been established.
4.	Turbidity, NTU, Max.	10	Above 10, Consumer acceptance decreases.	Essential	May be extended upto 25, in absence of alternative sources.
5.	pH Value	6.5 to 8.5	Beyond this range the water will affect the mucous membrane and/or water supply system.	Essential	May be relaxed upto 9.2 in absence of alternative sources.
6.	Total Hardness (as CaCO3) mg/l Max.	300	Encrustation in water supply structure and adverse effects on domestic use.	Essential	May be extended upto 600 in the absence of other sources.
7.	Calcium (as Ca), mg/l, Max.	75	Encrustation in water supply structure and adverse effects on domestic use.	Desirable	May be extended upto 200, in the absence of other sources.
8.	Magnesium (as Mg), mg/l, Max.	30	Encrustation in water supply structure and adverse effects on domestic use.	Desirable	May be extended upto 100, in the absence of other sources.
9.	Copper (as Cu), mg/l, Max.	0.05	Astringent taste, dis-coloration and corrosion of pipes fittings and utensils will be caused beyond this.	Desirable	May be relaxed upto 1.5.
10.	Iron (as Fe), mg/l, Max.	0.3	Beyond this limit taste/appearance are affected & has adverse effect on	Essential	May be extended upto 1.0 in absence of alternative

Sl. No.	Substance or Characteristics	Requirement Desirable Limit	Undesirable Effect Outside the Desirable Limit	Desirable/ Essential	Remarks
			domestic uses and water structures, and promotes iron bacteria		sources.
11.	Manganese (as Mn), mg/l, Max.	0.1	Beyond this limit, taste/appearance are affected on domestic uses and water supply structure.	Desirable	May be extended up to 0.5 where alternate source is not available.
12.	Sulphate (as SO4), mg/l, Max.	250	Beyond this causes gastrointestinal irrigation when magnesium of sodium are present .	Essential	May be extended up to 400 provided magnesium (as Mg) does not exceed 30.
13.	Chloride (as Cl), mg/l, Max.	250	Beyond this limit, taste, corrosion and palatability are affected	Essential	May be extended up to 1000 in the absence of other alternate sources.
14.	Nitrate (as NO3)mg/l, Max.	45	Beyond this mathemoglobinaemia takes place.	Desirable	No relaxation
15.	Fluoride (as F), mg/l	0.6 to 1.2	Low floride level are linked with dental carries above 1.5 it may cause fluorosis.	Desirable	If the limit is below 0.6 water source should be rejected but suitable public health measures should be taken.Maximum limit may be extended to 1.5 if no better alternate source is available.
16.	Phenolic Compounds (as C6H5OH), mg/l, Max.	0.001	Beyond this it may cause objectionable taste and odor.	Desirable	May be relaxed up to 0.002.
17.	Mercury (as Hg) mg/L, Max.	0.001	Beyond this the water becomes toxic.	Desirable	No relaxation of this limit is allowed to be tested when pollution is suspected.
18.	Cadmium (as Cd), mg/l, Max.	0.01	Beyond this the water becomes toxic.	Desirable	No relaxation of this limit is allowed to be tested when

Sl. No.	Substance or Characteristics	Requirement Desirable Limit	Undesirable Effect Outside the Desirable Limit	Desirable/ Essential	Remarks
					pollution is suspected.
19.	Selenium (as Se) mg/l, Max.	0.01	Beyond this the water becomes toxic.	Desirable	No relaxation of this limit is allowed to be tested when pollution is suspected.
20.	Arsenic (as as) mg/l, Max.	0.05	Beyond this the water becomes toxic.	Desirable	No relaxation of this limit is allowed to be tested when pollution is suspected
21.	Cyanide (as Cn) mg/l, Max.	0.05	Beyond this the water becomes toxic.	Desirable	No relaxation of this limit is allowed to be tested when pollution is suspected
22.	Lead (as Pb), mg/l, Max.	0.1	Beyond this the water becomes toxic.	Desirable	No relaxation of this limit is allowed to be tested when pollution is suspected
23.	Zinc (as Zn), mg/l, Max.	5.0	Beyond this limit it can cause astringent taste and an opalescence in water.	Desirable	May be relaxed up to 10.0. To be tested when pollution is suspected.
24.	Anionic detergents (as MBAS), mg/l, Max.	0.2	Beyond this limit it can cause a light froth in water.	Desirable	May be relaxed up to 1.0. To be tested when pollution is suspected.
25.	Chromium (as Cr+6) mg/l, Max.	0.05	May be carcinogenic.	Desirable	--
26.	Mineral Oil, mg/l, Max.	0.01	Beyond this limit undesirable taste and odor after chlorination takes place.	Desirable	May be relaxed up to 0.03. To be tested when pollution is suspected
27.	Residual free chlorine mg/l, Max.	0.2	--	Essential	

Water Conservation

Conservation of water mainly refers to protect, preserve, and control the usage of water and its resources. It is the system introduced to manage freshwater, reduce the wastage and protect the water and its resources in order to reduce and to avoid the scarcity. Therefore, we all should come forward to create awareness about conservation of water among our own friends, family, neighbors, society, etc. Conservation of water is very much essential as it saves life on earth.

Conserving water helps us by supplying more amount of water for longer usage. It has become necessary in all areas because these natural resources are reducing along with the increasing population and their usages.

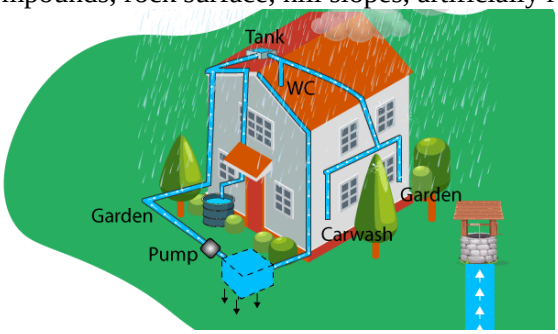
Rainwater Harvesting

The rainwater harvesting system is one of the best methods practiced and followed to support the conservation of water. Today, scarcity of good quality water has become a significant cause of concern. However, rainwater is pure and of good quality, can be used for irrigation, washing, cleaning, bathing, and cooking and also for other livestock requirements.

Rainwater harvesting systems consists of the following components:

- Catchment- Used to collect and store the captured rainwater.
- Conveyance system – It is used to transport the harvested water from the catchment to the recharge zone.
- Flush- It is used to flush out the first spell of rain.
- Filter – Used for filtering the collected rainwater and removing pollutants.
- Tanks and the recharge structures: Used to store the filtered water which is ready to use.

The process of rainwater harvesting involves the collection and the storage of rainwater with the help of artificially designed systems that run off naturally or man-made catchment areas like- the rooftop, compounds, rock surface, hill slopes, artificially repaired impervious or semi-pervious land surface.



Advantages of Rainwater Harvesting

The benefits of the rainwater harvesting system are listed below.

- Less cost.
- Helps in reducing the water bill.
- Decreases the demand for water.
- Reduces the need for imported water.
- Promotes both water and energy conservation.
- Improves the quality and quantity of groundwater.
- Does not require a filtration system for landscape irrigation.
- This technology is relatively simple, easy to install and operate.
- It reduces soil erosion, storm water runoff, flooding, and pollution of surface water with fertilizers, pesticides, metals and other sediments.
- It is an excellent source of water for landscape irrigation with no chemicals, dissolved salts and free from all minerals

Watershed Management:

The watershed area for a small stream may be a few hectares, while for a large river the watershed may be many square kilometers. For proper planning and execution, the size of a watershed area should ideally be

1,000 to 2,500 hectares. If the area is within this range, it will be possible to prepare a well-balanced plan and to implement it in a period of 2 to 3 years.

Objectives of Watershed management:

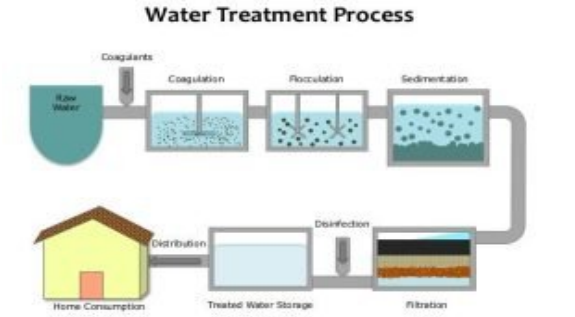
Watershed management is an attempt to halt land degradation and a holistic process for getting maximum production out of land. Watershed management implies rational utilization of land and water resources for optimum and sustained production, with the minimum of hazard to natural resources. With a bit of acumen and proper judgment, the rain water can be made to move down the slopes slowly, ensuring optimum infiltration and percolation, automatically solving the problem of soil erosion. Reducing the impact of the rain on the soil, checking its speed at various intervals, taking up all operations on the contour and diverting the excess to prevent the, pressure, are some of the procedures one could adopt; a process that starts at the highest point of the watershed and ends right down in the lower parts.

Steps in watershed management:

- Preparation of base maps for carrying out surveys.
- Reconnaissance survey of the watershed for overall development.
- Assessing rainfall characteristics.
- Preparation of soil maps and classification of lands for different uses according to capability classification for agriculture, forestry, pasture, horticulture, etc.
- Preparation of inventory of existing land uses and farm sizes.
- Appraisal of agricultural production patterns and potentials, present and potential markets and possible group action arrangements.
- Carrying out topographic and hydrologic surveys for engineering works.
- Geo-hydrological survey to delineate areas suitable for groundwater development.
- Formulation of an integrated time-bound plan for land and moisture conservation, ground water. Recharge, development of productive afforestation, agriculture production, grasslands and horticulture.
- Assigning of priorities for implementation of the project.
- Assessing social costs and benefits.

Water Treatment Process

Water from any source may contain various suspended, colloidal and dissolved impurities which may be harmful or useful for drinking purposes. **The process of removal of undesirable matters and pathogens from water is called the water treatment process.**



The degree of treatment depends upon the quality of water desired or required.

There are various impurities having sizes as:

1. Suspended Impurities – a size larger than 10^{-3} mm
2. Colloidal Impurities – a size between 10^{-3} mm to 10^{-6} mm
3. Dissolved Impurities – a size smaller than 10^{-6} mm

Objective of Water Treatment

Some of the main objectives of the water treatment process are:

1. To reduce the impurities to a certain level that does not cause harm to human health.
2. To reduce the objectionable color, odor, turbidity and hardness.
3. To make water safe for drinking.
4. To eliminate the corrosive nature of water affecting the pipe.
5. To make it suitable for a wide variety of industrial purposes such as steam generation, drying, etc.

Process of Water Treatment

The water treatment process includes many operations like screening, aeration and sedimentation, sedimentation with coagulation, softening, filtration, disinfection, etc.

The water treatment process generally adopted depends upon the quality of raw water and the quality of water derived. Methods of the water treatment process are explained below.

Screening

When water derived from the surface contain large suspended as well as floating matters which may be sticks, branches, leaves, etc.; the screens are fixed in the intake works or at the entrance of the treatment plant to remove the suspended as well as floating matters like branches, leaves and sticks.

Purpose of screening

1. To remove large suspended as well as floating matter such as leaves, branches, dead animals, etc.
2. To work as a protective device for a successive treatment.
3. To increase the efficiency of the successive.

Aeration

It is the process of bringing water to contact with atmospheric air that contains oxygen.

Aeration is one of the important operations for making water healthy and pure.

Purpose of Aeration

1. To remove taste and odor by gases due to organic decomposition.
2. To increase the dissolved oxygen.
3. To remove hydrogen sulphide that causes odor.
4. To decrease carbon dioxide in water.
5. To kill the bacteria to some extent.

Sedimentation

The process of the removal of suspended particles by gravitational settling is called sedimentation.

The water after screening may contain various suspended impurities like silt and clay particles. So to remove such particles sedimentation is done. The particle whose specific gravity is greater than that of water gets settles down under the action of gravity. Sedimentation tanks are designed to reduce the velocity of the flow of water so that the suspended particles get settled under the action of gravity. Sedimentation can be achieved in two ways.

Plain Sedimentation

When the suspended particles are separated under the action of gravity only, it is called plain sedimentation.

Sedimentation with coagulation & flocculation

Fine suspended particles and colloidal impurities are not removed by plain sedimentation. Particles of sizes 0.006 mm required 10 hours to settled in plain sedimentation.

Therefore we need certain chemicals to add in the water to remove such impurities which are not removed by plain sedimentation. These chemical are known as coagulants and the process is called sedimentation with coagulation. Examples of coagulants are $(Al_2SO_4)_3$, $AlSO_4$, odium aluminate, etc.

Filtration

Sedimentation and sedimentation with coagulation removes a large portion of suspended as well as colloidal particles which have specific gravity more than water. Some particles have a specific gravity less than or equal to water which cannot be settled by the process of sedimentation. For removing such particles and bacteria, odor and taste; another operation is needed. The process of passing water through beds of sands or gravels is known as filtration. It consists of a bed of sand supported on gravel.

Types of Filter

Slow Sand Filter

These are the initial type of filters introduced in 1829 in England. The rate of filtration through a slow sand filter is very slow. The rate of filtration is 100 to 200 liters per sq. m per hour.

Rapid Sand Filter

The rapid sand filter is mostly used for treatment works in municipalities. The rate of filtration work is 3000 to 6000-liter per square meter per hour.

Disinfection

A slow sand filter can remove up to 99% of pathogens. However, this percentage is less in the rapid sand filter. So to neutralize the effects of remaining organisms; the water is passed through the disinfection process. The killing of harmful bacteria with the help of chemicals or substances is called disinfection and chemical used are called disinfectants. Examples of disinfectants are hydrogen peroxide, formaldehyde, sodium hypochlorite phenol, etc. (Note: Sterilization is the process of elimination of organisms either they are useful or harmful.)

Volume Reduction in Wastewater Treatment

Volume reduction means those methods including, but not limited to biological, chemical, mechanical and thermal methods used to reduce the amount of space that waste materials occupy and to put them into a form suitable for storage or disposal.

By reducing the volume of wastewater sent to disposal, the service life of a well can be dramatically improved and deferring or eliminating the disposal well drilling costs can be an important factor in calculating life-cycle cost-effectiveness of water treatment.

Neutralization in Wastewater Treatment:

The aim of neutralization is to modify an acid or base water flow to a neutral pH (approximately 7). The most important objectives are to make the wastewater treatable using biological purification and/or make it comply with discharge criteria.

Factory wastes contain chemicals and harmful acids which may be harmful to the aquatic life and also lead to pollution of water. That's why factory waste is neutralized before disposing it into the water bodies. Lime is by far the most widely used neutralizing agent for industrial acidic waste waters. It is important, however, that the by-product, i.e. gypsum, can be used too. On laboratory experiment results with crystallization of gypsum, the chemical and physical parameters for an ideal by-product formation is discussed.

Precipitation method in wastewater treatment:

The process of precipitation/coagulation/flocculation transforms dissolved contaminants into insoluble solids, assisting in the contaminant's subsequent removal from the liquid phase through sedimentation or filtration. The process usually uses pH adjustment, addition of a chemical precipitant and flocculation.

Chemical precipitation can be used to remove contaminants from both municipal and industrial wastewaters. It can be used for water softening, heavy metal removal from metal plating wastes, oil and grease removal from emulsified solutions, and phosphate removal from wash-waters and other wastewater.

Questions Bank

1. Define water resource. Enlist various types of water resource and describe
2. Give and detail out classification of waters
3. Write note on origin of water
4. State the composition of water
5. Define domestic water & industrial water.
6. What are the characteristics of drinking water? Briefly describe each
7. What are the characteristics of Industrial wastewater water? Briefly describe each
8. What do you understand by BOD & COD?
9. Give standards of drinking water for any 3 parameters as per IS 10500-2012
10. Write brief note on Water Pollution (Prevention & Control) Act – 1974
11. Enumerate salient features of Water Pollution (Prevention & Control) Act – 1974
12. What do you mean by water conservation? Write the necessity & objective of water conservation
13. What is watershed? State why watershed management is important?
14. Describe the steps involved in watershed management
15. Describe the Rainwater Harvesting
16. State the advantages of rainwater harvesting
17. What are the stages of water treatment? Describe each briefly.
18. State and describe the process of water treatment
19. State the size of floating, suspended & dissolved impurities in the water.
20. Define Volume reduction in industrial water treatment
21. Define Neutralization in industrial water treatment
22. Define Precipitation methods in industrial water treatment

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VI Semester B Tech
Open Elective: Environment Engineering
Unit- III

Definition of Air Pollution

Air pollution refers to any physical, chemical, or biological change in the air. It is the contamination of air by harmful gases, dust, and smoke which affects plants, animals, and humans drastically.

There are a certain percentage of gases present in the atmosphere. An increase or decrease in the composition of these gases is harmful to survival. This imbalance in the gaseous composition has increased Earth's temperature which is known as global warming.

Chemical Composition of Air

Air is a mixture of gases which makes up the Earth's atmosphere. These gases are colorless and odorless and hence, we can't see them but only feel them. The atmosphere is an ocean of these gases. It consists of 78% nitrogen, 21% oxygen and 1 % other gases and water vapour. The composition of air does not change as you travel through the layers of the atmosphere. What changes is the number of molecules. The air molecules decrease and become less. The moisture content varies from place to place. Arid regions have less moisture content as compared to wetlands.

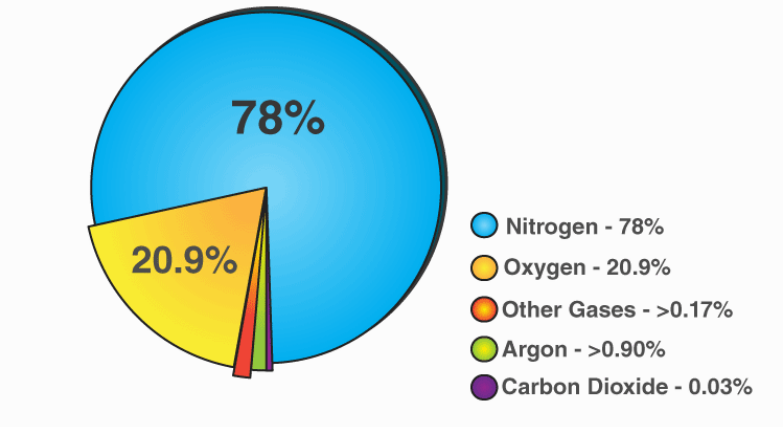
- The water vapour or moisture content of air varies. The maximum moisture carrying capacity of air depends primarily on temperature.
- The composition of air is unchanged until the elevation of approximately 10,000 m.
- The average air temperature diminishes at the rate of 0.6^{o}C for each 100 m vertical height.
- "One Standard Atmosphere" is defined as the pressure which is equal to that exerted by a 760 mm column of mercury at 0°C sea level and at standard gravity (32.174 ft/sec^{2}).

Layers of Earth's atmosphere are:

- Exosphere
- Thermosphere
- Mesosphere
- Stratosphere
- Troposphere

Around 2.4 billion people cook and heat their homes with polluting fuels and every year 3.2 million people die prematurely from household air pollution.

More than 99% of the population lives in areas where the air pollution is above WHO air quality guidelines and 4.2 million deaths are attributed to ambient air pollution each year.



Composition of Air					
Element	Volume by %	Weight by %	PPM(Parts per Million) by Volume	Symbol of the Element	Molecular Weight of the element
Nitrogen	78.08	75.47	780790	N_2	28.01
Oxygen	20.95	23.20	209445	O_2	32.00
Argon	0.93	1.28	9339	Ar	39.95
Carbon Dioxide	0.040	0.062	404	CO_2	44.01
Neon	0.0018	0.0012	18.21	Ne	20.18
Helium	0.0005	0.00007	5.24	He	4.00
Krypton	0.0001	0.0003	1.14	Kr	83.80
Hydrogen	0.00005	Negligible	0.50	H_2	2.02
Xenon	8.7×10^{-6}	0.00004	0.087	Xe	131.30

Other Components of Air

Some other components of air are mentioned below:

- Sulfur dioxide(SO_2) – 1.0 ppm
- Methane(CH_4)-2.0 ppm
- Nitrous oxide(N_2O) – 0.5 ppm
- Ozone(O_3)-0 to 0.07 ppm
- Nitrogen dioxide(NO_2) – 0.02 ppm
- Iodine(I_2)-0.01 ppm
- Carbon monoxide(CO) – 0 to trace ppm
- Ammonia(NH_3)-0 to trace ppm

Hope you have understood the composition of air in detail with the help of the chart given above. Let us know the properties of air.

Pollutants are the substances which cause pollution; air pollution is caused by air pollutants.

Types of Air Pollutants

Primary Pollutants	**Secondary Pollutants**
The pollutants that directly cause air pollution are known as primary pollutants.	The pollutants formed by the intermingling and reaction of primary pollutants are known as secondary pollutants.

Classification of Pollutants

Particulate Pollutants	Gaseous Pollutants	
1. Lead 2. Fly Ash 3. Metallic Oxides 4. Nanoparticles	1. Carbon monoxide (CO) 2. Carbon dioxide (CO2) 3. Chlorofluorocarbons (CFCs) 4. Ozone (O3)	• Volatile organic compounds (VOCs) • Benzene • Ethylene

	5. Nitrogen oxide (NOx) 6. Sulphur dioxide (SO2)	• Biological pollutants • Asbestos • Radon

Particulate Pollutants

The particles that pollute the air by being suspended can be defined as particulate pollutants.

These particles are results of some anthropogenic processes like vehicles, industries, construction sites/activities, etc. or natural sources like pollen, volcanic eruptions, natural gaseous precursors, etc.

- Their size ranges from 0.001 to 500 micrometers (μm) in diameter.

Heavy Particulate Matter	Suspended Particulate Matter	Nanoparticulate Matter
• More than 10 μm	• Less than 10 μm	• Less than 0.02 μm
• Settles down after a point	• Floats and moves freely with air currents	• Very light and harmful • Form aerosols

- Particulate pollutants can do vast damage to the human respiratory system.
- PM 2.5 particles (2.5 μm or less) are declared as one of the most harmful particulate pollutants by the Central Pollution Control Board (CPCB). They are so tiny that they can be detected only with the help of an electron microscope.
- These fine particulates can be inhaled deep into the lungs and can cause breathing and respiratory problems, irritation, inflammations, and pneumoconiosis (a disease of the lungs caused due to the inhalation of dust.
    - It is characterized by inflammation, coughing, and fibrosis – excess deposition of fibrous tissue).

Lead

- Lead is one of the most hazardous heavy metals.
- Lead can cause serious damage to the human body like:
    - Nervous system damage
    - Digestive issues
    - Kidney damage
    - Impacts on intelligence
- Hence, Lead was banned as an additive to fuels and other products.
- Lead mixed with water and food can create cumulative poisoning.
- It has long term effects on children as it lowers intelligence.

Fly Ash

- Fly Ash is particles of oxides and other heavy metals. The majority of them are aluminum silicate (in large amounts), silicon dioxide (SiO2), and calcium oxide (CaO).
- Thermal power plants are a major source of Fly Ash pollutants.
- Its deposition in agricultural fields can cause heavy metal contamination of crops and vegetables.

The Ministry of Environment and Forests has made it mandatory to use Fly Ash-based products in all construction projects, road embankment works, and low lying landfilling works that are within a 100 km radius of Thermal Power Stations and mine-filling activities within a 50 km radius of Thermal Power Stations.

Nanoparticles (NP)

- Nanoparticles have diameters less than 100 Nanometers (10-9).
- NP is responsible for the formation of dust clouds, Ozone depletion, environmental hydroxyl radical concentration, and stratospheric temperature changes.

To read about, Tuberculosis (TB) & National Strategic Plan for TB Elimination click here.

Gaseous Pollutants

Gaseous Pollutants	Description	Impacts

Carbon monoxide (CO)	• Highly toxic. • Produced from internal combustion engines due to incomplete combustion. • Other sources are volcanoes, forest fires, etc. • Greenhouse gas.	• Carbon monoxide poisoning. • Produces carboxyhemoglobin reducing the oxygen-carrying capacity of the blood.
Carbon dioxide (CO2)	• Heavier than air. • Source are volcanoes, fire, etc. • Greenhouse gas.	• CO2 is an asphyxiant gas (asphyxia: a condition arising when the body is deprived of oxygen, causing unconsciousness or death.). • Has other harmful effects if a high concentration of CO2 is inhaled like dizziness, headache, etc. • Carbonic rain in high polluted areas.
Chlorofluorocarbons (CFCs)	• Used in refrigerators, air conditioners, aerosols, etc.	• Highly destructive to the Ozone layer.
Ozone (O3)	• Very useful in the Stratosphere but harmful at the ground layer. • It's produced due to industries and vehicles. • Greenhouse gas.	• Has toxic effects. • Causes watery and itchy eyes.
Nitrogen oxide (NOx)	• Various oxides of Nitrogen come under NOX. • Caused due to the reaction between oxygen and nitrogen at high temps such as in combustion engines and industries.	• Aggravates Ashtamatic conditions and other respiratory issues in humans. • Plays a major role in the formation of SMOG, acid rain (nitric acid), and the greenhouse effect.
Sulphur dioxide (SO2)	• Pungent smelling colorless gas produced from mostly volcanic activities, industrial processes, and production of sulphuric acid.	• Respiratory issues, premature deaths, and death of certain nerves when inhaled.
Volatile Organic Compounds (VOCs)	• Volatile Organic Compounds (VOCs) are a large group of carbon-based chemicals that easily evaporate at room temperature.	• Irritations in eyes, skin, nose, and throat. • Long-term exposure can cause serious damage to the liver and other organs.
Benzene	• Found in petrochemicals and used as a fuel additive	• Increases cancer risk and a major cause of bone marrow failure.
Ethylene	• Used in plastic and chemical	• Excess exposure can cause

	industries in the production of Polyethylene and other polymers.	headaches and dizziness. • Ethylene oxide is a carcinogen.
Asbestos	• Occurs naturally as a fibrous mineral.	• Prolonged exposure and inhalation can be very harmful and can cause fatal illness.

Primary pollutants; Pollutants that enter directly from the sources into the atmosphere are called primary pollutants.

Secondary pollutants: Pollutants that are formed due to interactions between primary air pollutants and other atmospheric components are called secondary pollutants. These interactions can be physical or chemical.

Primary pollutants	Secondary pollutants
1. Have a direct effect on the environment and organisms and have an indirect effect by being involved in the formation of secondary pollutants.	1. Highly reactive when photochemical agents are involved in their formation.
2. Can be controlled by controlling man-made activities causing pollution.	2. These are difficult to control. because understanding the reactions involved in secondary pollutants formation is difficult.
3. For Example - i. Particulate matter like aerosols, soot, dust, etc. ii. HydrocarbonsHCs. iii. Sulphur dioxideSO2 iv. Nitrogen oxideNOx. v. Carbon monoxideCO.	3. For Example - i. Acid rain. ii. Photochemical smog. iii. Peroxyacetyl nitrate PAN

Ambient and household air pollution can come from similar processes such as incomplete combustion of fuels or chemical reactions between gases. However, the specific source of the combustion process can vary. For example, household activities such as cooking and heating with dirty technologies, and lighting with kerosene, emits a range of health harmful pollutants indoors, while activities such as high temperature combustion in vehicles, industries and power generating facilities contribute to ambient air pollution. Activities such as boiling water for bathing or cooking animal fodder can also add to household air pollution exposures.

Pollutants with the strongest evidence for public health concern include particulate matter (PM), carbon monoxide (CO), ozone (O_3), nitrogen dioxide (NO_2) and sulfur dioxide (SO_2). Health problems can occur as a result of both short- and long-term exposure to these various pollutants. For some pollutants, there are no thresholds below which adverse effects do not occur.

Pollutants which are included in the WHO global air quality guidelines are presented firstly followed by pollutants for which there are good practice statements but no quantitative values.

Particulate Matter Particulate matter (PM) refers to inhalable particles, composed of sulphate, nitrates, ammonia, sodium chloride, black carbon, mineral dust or water. PM can be of different size and is generally defined by their aerodynamic diameter, with $PM_{2.5}$ and PM_{10} the most common in the regulatory framework and relevant for health.

Sources of the largest particles called coarse particles (particles with diameter between 2.5 μm and 10 μm) will mainly consist of pollen, sea spray and wind-blown dust from erosion, agricultural spaces, roadways and mining operations. The finer particles (i.e., $PM_{2.5}$) can be derived from primary sources (e.g., combustion of fuels in power generation facilities, industries or vehicles) and secondary sources (e.g., chemical reactions between gases). The greatest source of particulate matter around the home is generally the combustion of polluting fuels in open hearths or poorly vented, inefficient stoves or space heaters. In addition to household activities like cooking, space heating, and lighting, other activities can

be important sources of particulate matter pollution in the home environment, such as preparing animal fodder, heating water for bathing and brewing beverages.

In outdoor environments, the main sources are location-specific and can be made up of different different origins but typically include traffic and transportation, industrial activities, power plants, construction sites, waste burning, fires or fields.

The health risks associated with particulate matter of less than 10 and 2.5 microns in diameter (PM_{10} and $PM_{2.5}$) are especially well documented. PM is capable of penetrating deep into the lung and enter the bloodstream causing cardiovascular (ischaemic heart disease), cerebrovascular (stroke) and respiratory impacts. Both long-term and short-term exposure to particulate matter is associated with morbidity and mortality from cardiovascular and respiratory diseases. Long-term exposure has been further linked to adverse perinatal outcomes and lung cancer. In 2013, it was classified as a cause of lung cancer by WHO's International Agency for Research on Cancer (IARC). It is also the most widely used indicator for assessing the health effects of exposure to air pollution.

Nitrogen dioxide (NO_2) is a reddish-brown gas that is soluble in water, and a strong oxidant. Ambient sources of NO_2 results from high temperature combustion of fuels in processes such as those used for heating, transportation, industry and power generation. Household sources of nitrogen oxides (NOx) include equipment that burn fuels such as furnaces, fireplaces and gas stoves and ovens. Exposure to nitrogen dioxide can irritate airways and aggravate respiratory diseases.

Ozone

Ground-level ozone (O_3) is a major component of smog. It is formed from photochemical reactions with pollutants such volatile organic compounds, carbon monoxide and nitrogen oxides (NOx) emitted from vehicles, and industry. Exposure to excessive ozone can cause problems breathing, trigger asthma, reduce lung function and lead to lung disease.

Carbon monoxide (CO) is a colourless, odourless gas produced by the incomplete combustion of carbonaceous fuels such as wood, petrol, coal, natural gas and kerosene in simple stoves, open fires, wick lamps, furnaces, fireplaces. The predominant source of carbon monoxide (CO) in ambient air is from motor vehicles. Carbon monoxide diffuses across the lung tissues and into the bloodstream, making it difficult for the body's cells to bind to oxygen. This lack of oxygen damages tissues and cells. Exposure to carbon monoxide can cause difficulties breathing, exhaustion, dizziness, and other flu-like symptoms. Exposure to high levels of carbon monoxide can be deadly.

Sulfur dioxide (SO_2) is a colourless gas that is readily soluble in water. It is predominantly derived from the combustion of fossil fuels for domestic heating, industries and power generation. Exposure to SO_2 is associated with asthma hospital admissions and emergency room visits.

Lead (Pb) and lead particulate compounds can be found in the home in contaminated dust from products such as paints, ceramics, pipes and plumbing materials, solders, gasoline, batteries, ammunition, and cosmetics. Lead can also be found in ambient air from vehicle exhaust of fuel with lead. Lead poses health risks of particular concern for children and pregnant women. The health impacts for children exposed to lead include behaviour and learning problems, lower IQ and hyperactivity, slowed growth, hearing problems, and anemia. In rare cases, ingestion of lead can cause seizures, coma and even death. Read more about lead poisoning here and here.

Polycyclic aromatic hydrocarbons (PAH) are present in the atmosphere in particulate form. They are a group of chemicals formed primarily from incomplete combustion of organic matter (e.g. cooking of meat) as well as fossil fuels in coke ovens, diesel engines and wood-burning stoves.

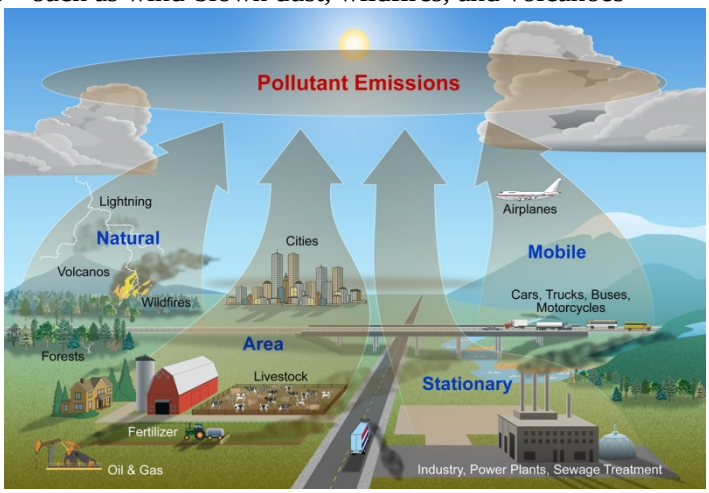
Formaldehyde

Formaldehyde is a colourless gas with a pungent smell. It is one of the most common volatile organic compounds (VOCs) found indoors. Formaldehyde is emitted from building materials (e.g. particleboard, plywood, glue, paints) as well as household and personal care products (e.g. drapes, carpets, cleaning products, hair sprays). Short-term exposure to formaldehyde can lead to eye, nose and throat irritation as well as increased allergic sensitization. However, long-term exposure to formaldehyde has been associated with nasopharyngeal cancer.

Types of Sources

There are four main types of air pollution sources:

- mobile sources – such as cars, buses, planes, trucks, and trains
- stationary sources – such as power plants, oil refineries, industrial facilities, and factories
- area sources – such as agricultural areas, cities, and wood burning fireplaces
- natural sources – such as wind-blown dust, wildfires, and volcanoes

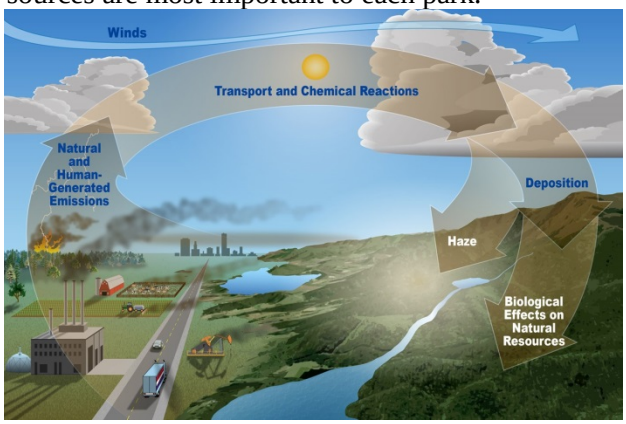


Mobile, stationary, area, and natural sources all emit pollution into the air.

Mobile sources account for more than half of all the air pollution in the United States and the primary mobile source of air pollution is the automobile, according to the Environmental Protection Agency. Stationary sources, like power plants, emit large amounts of pollution from a single location, these are also known as point sources of pollution. Area sources are made up of lots of smaller pollution sources that aren't a big deal by themselves but when considered as a group can be. Natural sources can sometimes be significant but do not usually create ongoing air pollution problems like the other source types can.

Pollution on the Move

Pollution from human-generated and natural sources is often created in one place and transported through the air. Sometimes chemical reactions in the atmosphere change pollutants before they are deposited. Pollutants in the air can create haze, making it harder to see, and pollutant deposition can have biological effects. NPS areas experience these effects just like other places. Location and even the time of year can determine which pollution sources are most important to each park.



Wind can move air pollutants short or very long distances before they cause harmful impacts.

Parks downwind of power plants that lack modern pollution controls can have increased smog. Tailpipe emissions from cars and trucks, as well as industrial processes such as oil and gas development, give rise to elevated ozone concentrations. Summertime wildfires can also reduce visibility in NPS areas. There are even examples of pollutants that originated from other countries and were transported thousands of miles

arriving at parks. The effects of this pollution can be seen as haze and through negative biological effects. Learn more about effects of air pollution on nature and visibility, and human health.

Introduction to Aerosols

Aerosol particles, microscopic bits of dust, soot, and sea spray suspended in the air, are the most poorly understood component of Earth's atmosphere.

Our atmosphere is made up primarily of gases—about 78% of the atmosphere is nitrogen (N2) and 21% is oxygen (O2), with the rest of it is made up of other gases. In addition to these gases, our atmosphere also contains very small liquid droplets and solid particles, known as particulate matter (PM). These particles play an important role in human health and climate, but are so small that when you look at the air around you, you usually can't see them with your bare eyes. In areas that are highly polluted with particulate matter, however, the difference is clear.

Aerosol particles come from a variety of sources—some are naturally occurring, while others are caused by human activities. Some of the sources of aerosol particles are illustrated in the figure below.

Human sources of aerosol particles include smoke from fires, vehicle exhaust, and factories. When hydrocarbon fuels (such as the gasoline in our cars) are burned, what happens? On a cold day, you may see smoke coming out of the exhaust pipe in your car, and maybe even some drops of water. When fuel is burned, it undergoes combustion. These aerosol particles are important to our community as well as our planet, as they can influence human health and the earth's climate.

Effects of Air Pollution

The hazardous effects of air pollution on the environment include:

Diseases

Air pollution has resulted in several respiratory disorders and heart diseases among humans. The cases of lung cancer have increased in the last few decades. Children living near polluted areas are more prone to pneumonia and asthma. Many people die every year due to the direct or indirect effects of air pollution.

Global Warming

Due to the emission of greenhouse gases, there is an imbalance in the gaseous composition of the air. This has led to an increase in the temperature of the earth. This increase in earth's temperature is known as global warming. This has resulted in the melting of glaciers and an increase in sea levels. Many areas are submerged underwater.

Acid Rain

The burning of fossil fuels releases harmful gases such as nitrogen oxides and sulphur oxides in the air. The water droplets combine with these pollutants, become acidic and fall as acid rain which damages human, animal and plant life.

Ozone Layer Depletion

The release of chlorofluorocarbons, halons, and hydrochlorofluorocarbons in the atmosphere is the major cause of depletion of the ozone layer. The depleting ozone layer does not prevent the harmful ultraviolet rays coming from the sun and causes skin diseases and eye problems among individuals.

Effect on Animals

The air pollutants suspend in the water bodies and affect aquatic life. Pollution also compels the animals to leave their habitat and shift to a new place. This renders them stray and has also led to the extinction of a large number of animal species.

Ozone

Ground-level ozone (O_3) is a major component of smog. It is formed from photochemical reactions with pollutants such volatile organic compounds, carbon monoxide and nitrogen oxides (NOx) emitted from vehicles, and industry. Exposure to excessive ozone can cause problems breathing, trigger asthma, reduce lung function and lead to lung disease.

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Air Quality Standards

Pollutant	Guideline value	Averaging time	Guideline reference	
$PM_{2.5}$	5 $\mu g/m^3$ 15 $\mu g/m^3$	Annual 24-hour	World Organization, 2021	Health
PM_{10}	15 $\mu g/m^3$ 45 $\mu g/m^3$	Annual 24-hour	World Organization, 2021	Health
Carbon monoxide	4 mg/m^3	24-hour	World Organization, 2021	Health

Nitrogen dioxide	10 μg/m^3 25 μg/m^3	Annual 24-hour	World Health Organization, 2021
Sulfur dioxide	40 mg/m^3	24-hour	World Health Organization, 2021
Formaldehyde	0.1 mg/m^3	30-minute	World Health Organization, 2010
Polycyclic aromatic hydrocarbons	8.7 × 10–5 per ng/m^3		World Health Organization, 2010
Radon	100 Bq/m^3		World Health Organization, 2010
Lead	0.5 μg/m^3	Annual	World Health Organization. Regional Office for Europe, 2000

Air Pollution (Prevention & Control) Act – 1981

The Air (Prevention and Control of Pollution) Act of 1981, or the Air Act, in short, was a law passed by the Parliament of India to prevent and control the harmful effects of air pollution in India. This act is seen as the first concrete step taken by the government of India to combat air pollution.

The effects of climate change caused by all forms of pollution became all too apparent in the early 1970s. To mitigate their harmful effects it was believed that nations would need to pass their own laws. Thus during the United Nations General Assembly on Human Environment held in Stockholm in June 1972, a resolution was passed which implored the nations of the world to preserve natural resources such as air.

India itself had issues regarding air pollution due to a wide variety of factors such as stubble burning, improper industrial practices, environmental factors etc. To combat these factors a special law was enacted under the Constitution of India, which was the Air (Prevention and Control of Pollution) Act of 1981.

- Section 2(a) defines an 'air pollutants' as any solid liquid or gaseous substance which may cause harm or damage the environment, humans, plants, animals or even damage property. A 1987 amendment to the act also added 'noise' in the list of harmful substances.
- The air act defines 'air pollution' as the presence of any dangerous pollutant that makes the air unbreathable

Section 2 (g) of the Act also set up the Central Pollution Control Board (CPCB) whose powers extended to the whole of India. To carry out the directives of the CPCB the act also called for the setting up of the State Pollution Control Board (SPCB) for the individual states of India

Penalties and Procedure under the Air Act

The failure to comply with the Central Pollution Control Board directives would result in imprisonment of 1 year. It can be extended to 6 years with a fine with the additional fine of 5000Rs per day added provided the directives are still not met.

Any environmental complaint will only be taken into consideration by a court if it is made by the following:

- An officer authorised by the CPCB
- A person who has made a complaint to the board or an officer authorised by it. The complaint must be made within sixty days of the offence committed

Meteorological factors

Air movements influence the fate of air pollutants. So any study of air pollution should include a study of the local weather patterns (meteorology).

If the air is calm and pollutants cannot disperse, then the concentration of these pollutants will build up. On the other hand, when strong, turbulent winds blow, pollutants disperse quickly, resulting in lower pollutant concentrations.

Wind speed and direction

When high pollutant concentrations occur at a monitoring station, wind data records can determine the general direction and area of the emissions. Identifying the sources means planning to reduce the impacts on air quality can take place.

An instrument called an anemometer measures wind speed. At our monitoring stations, the type of anemometer we use is a sonic anemometer.

A sonic anemometer operates on the principle that the speed of wind affects the time it takes for sound to travel from one point to another. Sound travelling with the wind will take less time than sound travelling into the wind. By measuring sound wave speeds in 2 different directions at the same time, sonic anemometers can measure both wind speed and direction.

Temperature

Measuring temperature supports air quality assessment, air quality modelling and forecasting activities.

Temperature and sunlight (solar radiation) play an important role in the chemical reactions that occur in the atmosphere to form photochemical smog from other pollutants.

Favourable conditions can lead to increased concentrations of smog.

The most common way of measuring temperature is to use a material with a resistance that changes with temperature, such as platinum wire. A sensor measures this change and converts it into a temperature reading.

Humidity

Like temperature and solar radiation, water vapour plays an important role in many thermal and photochemical reactions in the atmosphere. As water molecules are small and highly polar, they can bind strongly to many substances. If attached to particles suspended in the air they can significantly increase the amount of light scattered by the particles If the water molecules attach to corrosive gases, such as sulfur dioxide, the gas will dissolve in the water and form an acid solution that can damage health and property.

Water vapour content of air is reported as a percentage of the saturation vapour pressure of water at a given temperature. This is the relative humidity. The amount of water vapour in the atmosphere is highly variable—it depends on geographic location, how close water bodies are, wind direction and air temperature. Relative humidity is generally higher during summer when temperature and rainfall are also at their highest. Measuring humidity uses the absorption properties of a polymer film. The film either absorbs or loses water vapour as the relative humidity of the ambient air changes. A sensor measures these changes and converts them into a humidity reading.

Rainfall

Rain has a 'scavenging' effect when it washes particulate matter out of the atmosphere and dissolves gaseous pollutants. Removing particles improves visibility. Where there is frequent high rainfall, air quality is generally better. If the rain dissolves gaseous pollutants, such as sulfur dioxide, it can form acid rain resulting in potential damage to materials or vegetation.

Solar radiation

It is important to monitor solar radiation for use in modelling photochemical smog events, as the intensity of sunlight has an important influence on the rate of the chemical reactions that produce the smog. The cloudiness of the sky, time of day and geographic location all affect sunlight intensity.

An instrument called a pyranometer measures solar radiation from the output of a type of silicon cell sensor.

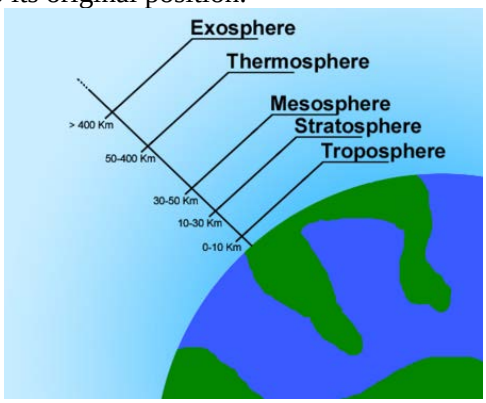
Environmental Lapse Rate

Normally, the earth's surface gets warmed by the short-wave radiation from the sun. This makes the air near the earth's surface become heated. Eventually, this air becomes less dense and rises upwards. As it rises, it transfers heat through the process known as convection. The heated air rises upwards as a parcel; thus, it is commonly described as a parcel of air or air parcel.

As the air parcel continues rising, its pressure decreases forcing it to expand. Its expansion helps to maintain a balance between its internal pressure and external pressure. As a result, the air parcel cools, and its temperature decreases. Temperature changes of air as it moves upwards the atmosphere are normally observed as the altitude increases.

Altitude is defined as the height above sea level. So, what is the lapse rate? This is the rate at which the temperature changes with altitude. However, the standard rate of temperature change with altitude is known as the environmental lapse rate or the standard lapse rate. This rate is estimated to be 6.5 degrees Celsius per kilometer or 1000 meters.

The environmental lapse rate is influenced by various factors such as temperature, altitude, air pressure of air parcel, and other heat exchange processes such as radiation (heat traveling through space at the speed of light), convection, and condensation (heat transfer through the collision of neighboring atoms or molecules). The environmental lapse rate plays an important role in determining the stability of the rising air. The effects of a lower environmental lapse rate ensure the cooling of the rising air, which ultimately loses its buoyancy and returns to its original position.



Temperature Inversion

Under normal circumstances, the temperature in the troposphere declines at a rate of 1 degree per 165 metres as height rises. This is referred to as the usual lapse rate. However, in rare circumstances, the scenario is reversed, and the temperature rises rather than falls with height. Temperature inversion is the term for this.

Temperature inversion refers to a reverse of the troposphere's typical temperature pattern. A warm air's layer sits over the cold air layer in this meteorological occurrence.

After understanding what is temperature inversion, let us move further to what causes temperature inversion and temperature inversion diagram. Here is the temperature inversion diagram:

It is caused by static atmospheric conditions, although it can also be caused by horizontal or vertical air movement. Temperature inversions are usually short-lived, but they are pretty common.

Favourable Conditions for Temperature Inversion

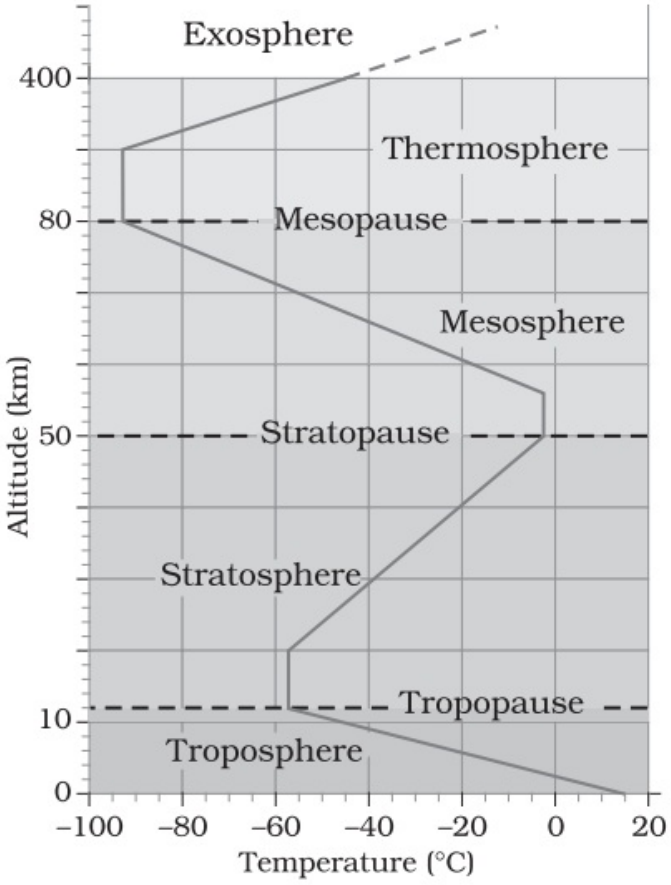
- Long winter nights: Heat loss from the earth’s surface due to terrestrial radiation may exceed the amount of incoming solar radiation during the night.
- When the sky is clear and there are no clouds, heat is lost more quickly through terrestrial radiation.
- Dry air near the ground surface: It prevents radiated heat from the Earth's surface from being absorbed.
- Slow air movement: There is no heat transmission or mixing in the lower levels of the atmosphere due to this.

- Snow-covered ground surfaces result in the most significant heat loss due to the reflection of incoming solar energy.

Temperature Inversion Effects

Here are some common temperature inversion effects:

- Cloud formation, visibility, and precipitation are all influenced by inversions.
- The upward movement of air from the layers below is slowed by an inversion. As a result, convection caused by below-inversion heating is limited to levels below the inversion. Dust, smoke, and other air pollutants are also limited in their spread.
- Convective clouds cannot develop high enough to produce showers in areas where there is a strong low-level inversion.
- Due to the accumulation of dust and smoke particles below the inversion, visibility may be considerably decreased. Fog is typically prevalent towards the base of an inversion because the air is cold.
- Temperature diurnal variations are also affected by inversions. The difference between the hours of the day and the hours of the night is usually relatively minor.



Energy Conservation

A large number of fossil fuels are burnt to generate electricity. Therefore, do not forget to switch off the electrical appliances when not in use. Thus, you can save the environment at the individual level. Use of energy-efficient devices such as CFLs also controls pollution to a greater level.

Use of Clean Energy Resources

The use of solar, wind and geothermal energies reduce air pollution at a larger level. Various countries, including India, have implemented the use of these resources as a step towards a cleaner environment.

Other air pollution control measures include:

1. By minimising and reducing the use of fire and fire products.
2. Since industrial emissions are one of the major causes of air pollution, the pollutants can be controlled or treated at the source itself to reduce its effects. For example, if the reactions of a certain raw material yield a pollutant, then the raw materials can be substituted with other less polluting materials.
3. Fuel substitution is another way of controlling air pollution. In many parts of India, petrol and diesel are being replaced by CNG – Compressed Natural Gas fueled vehicles. These are mostly adopted by vehicles that aren't fully operating with ideal emission engines.
4. Although there are many practices in India, which focus on repairing the quality of air, most of them are either forgotten or not being enforced properly. There are still a lot of vehicles on roads which haven't been tested for vehicle emissions.
5. Another way of controlling air pollution caused by industries is to modify and maintain existing pieces of equipment so that the emission of pollutants is minimised.
6. Sometimes controlling pollutants at the source is not possible. In that case, we can have process control equipment to control the pollution.
7. A very effective way of controlling air pollution is by diluting the air pollutants.
8. The last and the best way of reducing the ill effects of air pollution is tree plantation. Plants and trees reduce a large number of pollutants in the air. Ideally, planting trees in areas of high pollution levels will be extremely effective.

National Green Tribunal

National Green Tribunal (NGT) was established on 18th October 2010 under the NGT Act of 2010 as a specialized body for handling any environmental disputes that involve multi-disciplinary issues. It was formed by replacing the National Environment Appellate Authority. It also draws inspiration from Article 21 of the India Constitution which assures to provide a healthy environment to the citizens of India.

Objectives of National Green Tribunal (NGT)

Some of the major objectives of the National Green Tribunal (NGT) are as follows:

- Effective and expeditious disposal of cases that are related to the protection and conservation of the environment, forests, and other natural resources.
- To give relief and compensations for any damages caused to persons and properties.
- To handle various environmental disputes that involve multi-disciplinary issues.

Structure of NGT

The National Green Tribunal (NGT) comprises three major bodies namely:

1. The Chairperson
2. The Judicial Members, and
3. The Expert Members.

Also, there should be a minimum of 10 and a maximum of 20 fulltime Judicial as well as Expert members in the NGT.

Role of NGT

Over the past few years, the National Green Tribunal (NGT) developed as an important body for regulation of the environment and passing strict orders on issues related to pollution, deforestation, waste management, etc. Some of the major powers of the National Green Tribunal include:

- NGT provides a way for the evolution of environmental jurisprudence through the development of an alternative dispute resolution mechanism.
- It helps in the reduction of the litigation burden on environmental matters in the higher courts.
- NGT provides a faster solution for various environment-related disputes that are less formal and less expensive.
- It curbs environment-damaging activities. NGT ensures the strict observation of the Environment Impact Assessment (EIA) process.
- NGT provides reliefs and compensations for any damages caused to persons and properties.
- The National Green Tribunal resolves various civil cases under the following seven laws that are related to the environment:

Central Pollution Control Board (CPCB)

The Central Pollution Control Board (CPCB), statutory organisation, was constituted in September, 1974 under the Water (Prevention and Control of Pollution) Act, 1974. Further, CPCB was entrusted with the powers and functions under the Air (Prevention and Control of Pollution) Act, 1981.

It serves as a field formation and also provides technical services to the Ministry of Environment and Forests of the provisions of the Environment (Protection) Act, 1986. Principal Functions of the CPCB, as spelt out in the Water (Prevention and Control of Pollution) Act, 1974, and the Air (Prevention and Control of Pollution) Act, 1981, (i) to promote cleanliness of streams and wells in different areas of the States by prevention, control and abatement of water pollution, and (ii) to improve the quality of air and to prevent, control or abate air pollution in the country.

Air Quality Monitoring is an important part of the air quality management. The National Air Monitoring Programme (NAMP) has been established with objectives to determine the present air quality status and trends and to control and regulate pollution from industries and other source to meet the air quality standards. It also provides background air quality data needed for industrial siting and towns planning.

Besides this, CPCB has an automatic monitoring station at ITO Intersection in New Delhi. At this station Respirable Suspended Particulate Matter (RSPM), Carbon Monoxide (CO), Ozone (O3), Sulphur Dioxide (SO2), Nitrogen Dioxide (NO2) and Suspended Particulate Matter (SPM) are being monitored regularly. This information on Air Quality at ITO is updated every week.

Water Quality Monitoring is an important part of the Water quality management. Fresh water is a finite resource essential for use in agriculture, industry, propagation of wildlife & fisheries and for human existence. India is a riverine country. It has 14 major rivers, 44 medium rivers and 55 minor rivers besides numerous lakes, ponds and wells which are used as primary source of drinking water even without treatment. Most of the rivers being fed by monsoon rains, which is limited to only three months of the year, run dry throughout the rest of the year often carrying wastewater discharges from industries or cities/towns endangering the quality of our scarce water resources. The parliament of India in its wisdom enacted the Water (Prevention and Control of Pollution) Act, 1974 with a view to maintaining and restoring wholesomeness of our water bodies. One of the mandates of CPCB is to collect, collate and disseminate technical and statistical data relating to water pollution. Hence, Water Quality Monitoring (WQM) and Surveillance are of utmost importance.

Functions of the Central Board at the National Level

- Advise the Central Government on any matter concerning prevention and control of water and air pollution and improvement of the quality of air.
- Plan and cause to be executed a nation-wide programm for the prevention, control or abatement of water and air pollution;
- Co-ordinate the activities of the State Board and resolve disputes among them;
- Provide technical assistance and guidance to the State Boards, carry out and sponsor investigation and research relating to problems of water and air pollution, and for their prevention, control or abatement;
- Plan and organise training of persons engaged in programme on the prevention, control or abatement of water and air pollution;
- Organise through mass media, a comprehensive mass awareness programme on the prevention, control or abatement of water and air pollution;
- Collect, compile and publish technical and statistical data relating to water and air pollution and the measures devised for their effective prevention, control or abatement;

- Prepare manuals, codes and guidelines relating to treatment and disposal of sewage and trade effluents as well as for stack gas cleaning devices, stacks and ducts;
- Disseminate information in respect of matters relating to water and air pollution and their prevention and control;
- Lay down, modify or annul, in consultation with the State Governments concerned, the standards for stream or well, and lay down standards for the quality of air; and
- Perform such other function as may be prescribed by the Government of india.
  Functions of the Central Board as State Boards for the Union Territories

- Advise the Governments of Union Territories with respect to the suitability of any premises or location for carrying on any industry which is likely to pollute a stream or well or cause air pollution; Lay down standards for treatment of sewage and trade effluents and for emissions from automobiles, industrial plants, and any other polluting source; Evolve efficient methods for disposal of sewage and trade effluents on land; develop reliable and economically viable methods of treatment of sewage, trade effluent and air pollution control equipment; Identify any area or areas within Union Territories as air pollution control area or areas to be notified under the Air (Prevention and Control of Pollution) Act, 1981; Assess the quality of ambient water and air, and inspect wastewater treatment installations, air pollution control equipment, industrial plants or manufacturing process to evaluate their performance and to take steps for the prevention, control and abatement of air and water pollution.
  As per the policy decision of the Government of India, the CPCB has delegated its powers and functions under the Water (Prevention and Control of Pollution) Act, 1974, the Water (Prevention and Control of Pollution) Cess Act, 1977 and the Air (Prevention and Control of Pollution) Act, 1981 with respect to Union Territories to respective local administrations. CPCB along with its counterparts State Pollution Control Boards (SPCBs) are responsible for implementation of legislations relating to prevention and control of environmental pollution.

Maharashtra State Pollution Control Board (MSPCB)

Maharashtra Pollution Control Board (MPCB) is implementing various environmental legislations in the state of Maharashtra, mainly including Water (Prevention and Control of Pollution) Act, 1974, Air (Prevention and Control of Pollution) Act, 1981 and some of the provisions under Environmental (Protection) Act, 1986 and the rules framed there under like, Biomedical Waste (M&H) Rules, 1998, Hazardous Waste (M&H) Rules, 2000, Municipal Solid Waste Rules, 2000 etc. MPCB is functioning under the administrative control of Environment Department of Government of Maharashtra.

Some of the important functions of MPCB are:

- To plan comprehensive program for the prevention, control or abatement of pollution and secure executions thereof,
- To collect and disseminate information relating to pollution and the prevention, control or abatement thereof,
- To inspect sewage or trade effluent treatment and disposal facilities, and air pollution control systems and to review plans, specification or any other data relating to the treatment plants, disposal systems and air pollution control systems in connection with the consent granted,
- Supporting and encouraging the developments in the fields of pollution control, waste recycle reuse, eco-friendly practices etc.
- To educate and guide the entrepreneurs in improving environment by suggesting appropriate pollution control technologies and techniques
- Creation of public awareness about the clean and healthy environment and attending the public complaints regarding pollution.

VI Semester B Tech
Open Elective: Environment Engineering
Unit- IV

Bureau of Energy Efficiency (BEE)

The Government of India set up Bureau of Energy Efficiency (BEE). on 1st March 2002 under the provisions of the Energy Conservation Act, 2001. The mission of the Bureau of Energy Efficiency is to assist in developing policies and strategies with a thrust on self-regulation and market pri nciples, within the overall framework of the Energy Conservation Act, 2001 with the primary objective of reducing energy intensity of the Indian economy.

Role of BEE

BEE co-ordinates with designated consumers, designated agencies and other organizations and recognize, identify and utilize the existing resources and infrastructure, in performing the functions assigned to it under the Energy Conservation Act. The Energy Conservation Act provides for regulatory and promotional functions.

The Major Promotional Functions of BEE include:

1	Create awareness and disseminate information on energy efficiency and conservation
2	Arrange and organize training of personnel and specialists in the techniques for efficient use of energy and its conserv
3	Strengthen consultancy services in the field of energy conservation
4	Promote research and development
5	Develop testing and certification procedures and promote testing facilities
6	Formulate and facilitate implementation of pilot projects and demonstration projects
7	Promote use of energy efficient processes, equipment, devices and systems
8	Take steps to encourage preferential treatment for use of energy efficient equipment or appliances
9	Promote innovative financing of energy efficiency projects
10	Give financial assistance to institutions for promoting efficient use of energy and its conservation
11	Prepare educational curriculum on efficient use of energy and its conservation
12	Implement international co-operation programmes relating to efficient use of energy and its conservation

National Action Plan on Climate change

The National Action Plan on Climate change was formally launched on June 30th, 2008. The NAPCC identifies measures that promote development objectives while also yielding co-benefits for addressing climate change effectively.

As part of the Climate Change Action program, the scheme has been extended upto 2025-26. It consists of eight broad sub-components including the National Action Plan on Climate Change (NAPCC) coordination, State Action Plan on Climate Change (SAPCC), National Institute on Climate Change Studies & Actions, National Carbonaceous Aerosols Programme (NCAP), Long Term Ecological Observations (LTEO), International negotiations and capacity building.

There are eight “National Missions” which form the core of the NAPCC. They focus on promoting understanding of climate change, adaptation and mitigation, energy efficiency and natural resource conservation.”

The eight missions are:

- National Solar Mission
- National Mission for Enhanced Energy Efficiency
- National Mission on Sustainable Habitat
- National Water Mission

- National Mission for Sustaining the Himalayan Ecosystem
- National Mission for a Green India
- National Mission for Sustainable Agriculture
- National Mission on Strategic Knowledge for Climate Change

i. National Solar Mission

Great importance has been given to the National Solar Mission in the NAPCC. The objective of the mission is to increase the share of solar energy in the total energy mix of the country, while also expanding the scope of other renewable sources. The mission also calls for the launch of a research and development (R&D) programme that, with the help of international cooperation, would look into creating more cost-effective, sustainable and convenient solar power systems.

The ambitious goal is to achieve 280GW of installed solar capacity by 2030. The Mission also targets installing 100 GW grid-connected solar power plants by the year 2022.

ii. National Mission for Enhanced Energy Efficiency

The Government of India already has a number of initiatives to promote energy efficiency. In addition to these, the NAPCC calls for:

- Mandating specific energy consumption decreases in large energy consuming industries and creating a framework to certify excess energy savings along with market based mechanisms to trade these savings.
- Innovative measures to make energy efficient appliances/products in certain sectors more affordable.
- Creation of mechanisms to help finance demand side management pro-grammes by capturing future energy savings and enabling public-private-partnerships for this.
- Developing fiscal measures to promote energy efficiency such as tax incentives for including differential taxation on energy efficient certified appliances.

iii. National Mission on Sustainable Habitat

The aim of the Mission is to make habitats more sustainable through a threefold approach that includes:

- Improvements in energy efficiency of buildings in residential and commercial sector
- Management of Municipal Solid Waste (MSW)
- Promote urban public transport

iv. National Water Mission

The National Water Mission aims at conserving water, minimizing wastage and ensuring more equitable distribution through integrated water resource management. The Water Mission will develop a framework to increase the water use efficiency by 20%. It calls for strategies to tackle variability in rainfall and river flows such as enhancing surface and underground water storage, rainwater harvesting and more efficient irrigation systems like sprinklers or drip irrigation.

v. National Mission for Sustaining the Himalayan Ecosystem

The Plan calls for empowering local communities especially Panchayats to play a greater role in managing ecological resources. It also reaffirms the following measures mentioned in the National Environment Policy, 2006.

- Adopting appropriate land-use planning and water-shed management practices for sustainable development of mountain ecosystems
- Adopting best practices for infrastructure construction in mountain regions to avoid or minimize damage to sensitive ecosystems and despoiling of landscapes
- Encouraging cultivation of traditional varieties of crops and horticulture by promoting organic farming, enabling farmers to realize a price premium
- Promoting sustainable tourism based on best practices and multi-stakeholder partnerships to enable local communities to gain better livelihoods
- Taking measures to regulate tourist inflows into mountain regions to ensure that the carrying capacity of the mountain ecosystem is not breached
- Developing protection strategies for certain mountain scopes with unique “incomparable values”

vi. National Mission for a Green India
This Mission aims at enhancing ecosystem services such as carbon sinks. It builds on the Prime Minister's Green India campaign for afforestation of 6 million hectares and the national target of increasing land area under forest cover from 23% to 33%. It is to be implemented on degraded forest land through Joint Forest Management Committees set up under State Departments of Forests. These Committees will promote direct action by communities.

vii. National Mission for Sustainable Agriculture
The aim is to make Indian agriculture more resilient to climate change by identifying new varieties of crops, especially thermal resistant ones and alternative cropping patterns. This is to be supported by integration of traditional knowledge and practical systems, information technology and biotechnology, as well as new credit and insurance mechanisms.

viii. National Mission on Strategic Knowledge for Climate Change.
This Mission strives to work with the global community in research and technology development and collaboration through a variety of mechanisms and, in addition, will also have its own research agenda supported by a network of dedicated climate change related institutions and universities and a Climate Research Fund. The Mission will also encourage private sector initiatives for developing innovative technologies for adaptation and mitigation.

Implementation of Missions
The 8 National Missions are to be institutionalized by "respective ministries" and will be organized through inter-sectoral groups including, in addition to related Ministries, Ministry of Finance and the Planning Commission, experts from industry, academia and civil society.

National Mission for Enhanced Energy Efficiency (NMEEE)
National Action Plan on Climate Change wanted to tackle the energy aspect, which resulted in the formulation of the National Mission for Enhanced Energy Efficiency. It was introduced with an objective to promote the market for energy efficiency by encouraging innovation.
The National Mission for Enhanced Energy Efficiency (NMEEE) is one of the eight national missions under the National Action Plan on Climate Change (NAPCC).
The basis for the introduction of this mission was The Energy Conservation Act of 2001. As per the mission document that was approved in 2010, it was established that the energy efficiency potential in India was to the tune of Rs 74,000 crores. The mission estimates that upon successful execution of the mission, there would be fuel savings to the tune of 23 million tonnes per year, and the greenhouse gas emissions would reduce to the tune of 98.55 million tonnes per year.

Schemes under NMEEE
1. Perform Achieve and Trade Scheme (PAT)
2. Market Transformation for Energy Efficiency (MTEE)
3. Energy Efficiency Financing Platform (EEFP)
4. Framework for Energy Efficient Economic Development (FEEED)

Perform Achieve and Trade Scheme
This is applicable for large scale energy-intensive industries. It is a market-based mechanism to improve on the cost-effectiveness of energy efficiency and certification of energy savings that could be traded.

Market Transformation for Energy Efficiency
Give more thrust to innovations to produce appliances that are completely affordable and energy-efficient.
Energy Efficiency Financing Platform
Ensuring that there is adequate finance at reasonable rates for energy efficiency project implementation.

Framework for Energy Efficient Economic Development
Developing fiscal instruments to promote energy efficiency
This initiative is undertaken with the objective of addressing the concerns of investors and banks that are averse to taking risks. This scheme provides innovative fiscal instruments. BEE started 2 different types of funds with the objective of boosting the confidence of investors and banks thereby avoiding the risk of projects getting stalled due to lack of funds. The 2 types of funds are

1. Partial Risk Guarantee Fund for Energy Efficiency
2. Venture Capital Fund for Energy Efficiency.

Who are the implementing agencies for NMEEE?

1. Bureau of Energy Efficiency (BEE)
2. Energy Efficiency Services Limited (EESL)

It is estimated that total energy savings of about 26 MTOE translating into avoiding about 70 million tonnes of CO2 will be achieved by March 2023.

Kyoto Protocol

The Kyoto Protocol is an international and legally binding agreement to reduce greenhouse gas emissions worldwide. It came into force on 16th February 2005. The major feature of the Kyoto Protocol is that it sets binding targets for industrialized countries for reducing greenhouse gas (GHG) emissions. The greenhouse gases include carbon dioxide, methane, nitrous oxide, sulphur hexafluoride, hydrofluorocarbons and perfluorocarbons. As of 2008, 183 parties have ratified the protocol, which includes India.

Recognizing that developed countries are principally responsible for the current high levels of GHG emissions in the atmosphere as a result of more than 150 years of industrial activity, the Protocol places a heavier burden on developed nations under the principle of “common but differentiated responsibilities.” Under the protocol, the developed countries are required to reduce emissions of GHGs by an average of 5.2 per cent below 1990 levels by 2012.

The Kyoto mechanisms

Under the Treaty, countries must meet their targets primarily through national measures. However, the Kyoto Protocol offers them an additional means of meeting their targets by way of three market-based mechanisms.
They are:

- Emissions trading – known as “the carbon market">
- Clean development mechanism (CDM)
- Joint implementation (JI).

a. Emissions trading - Carbon trading

Countries with commitments under the Kyoto Protocol have accepted targets for limiting or reducing emissions. These targets are expressed as levels of allowed emissions, or “assigned amounts”. The allowed emissions are divided into “assigned amount units” (AAUs).
The Kyoto Protocol allows countries that have emission units to spare (emissions permitted to them but not "used") to sell this excess capacity to countries that are over their targets.
Thus, a new commodity was created in the form of emission reductions or removals. Since carbon dioxide is the principal greenhouse gas, it was termed carbon trading. Carbon is now tracked and traded like any other commodity. This is often termed the carbon market.
Other trading units in the carbon market
The other units which may be transferred under the scheme, each equal to one tonne of CO2, may be in the form of:

- A removal unit (RMU) on the basis of land use, land-use change and forestry (LULUCF) activities such as reforestation
- An emission reduction unit (ERU) generated by a joint implementation project
- A certified emission reduction (CER) generated from a clean development mechanism project activity

b. Clean Development Mechanism

The Clean Development Mechanism (CDM), defined in Article 12 of the Protocol, allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction (CER) credits, each equivalent to one tonne of CO2, which can be counted towards meeting Kyoto targets.

A CDM project activity might involve, for example, a rural electrification project using solar panels or the installation of more energy-efficient boilers. The mechanism stimulates sustainable development and emission reductions, while giving industrialized countries some flexibility in how they meet their emission reduction or limitation targets.

A CDM project must provide emission reductions that are additional to what would otherwise have occurred. The projects must qualify through a rigorous and public registration and issuance process. Approval is given by the Designated National Authorities. Public funding for CDM project activities must not result in the diversion of official development assistance.

c. Joint implementation

The mechanism known as "joint implementation," defined in Article 6 of the Kyoto Protocol, allows a country with an emission reduction or limitation commitment under the Kyoto Protocol to earn emission reduction units (ERUs) from an emission-reduction or emission removal project in another country, each equivalent to one tonne of CO2, which can be counted towards meeting its Kyoto target.

Energy Conservation Building Code (ECBC)

The Energy Conservation Building Code (ECBC) set minimum energy performance standards for commercial buildings. Under section 14 (p) of the Energy Conservation Act, 2001, Central Government has powers to prescribe ECBC for non-residential buildings, having connected load of 100 KW and above or a contract demand of 120 KVA and above or recommended built-up area of 1000 sqm and above. or building complex for efficient use of energy and its conservation. The state governments have the flexibility to modify ECBC to suit local or regional needs. Energy performance standards for the following building systems will be included in the ECBC:

- Building Envelope
- Heating Ventilation and Air Conditioning
- Lighting
- Service Water Heating
- Electric Power and Distribution

The Energy Conservation Building Code (ECBC) was launched in May 2007 by the Bureau of Energy Efficiency (BEE), Ministry of Power. Its main objective is to establish minimum requirements for energy efficient design and construction of buildings.

New Construction

The Energy Conservation Building Code (ECBC) was developed by the Govt. of India for new commercial buildings on 27th May 2007. ECBC sets minimum energy standards for commercial buildings having a connected load of 100kW or contract demand of 120 KVA and above. While the Central Government has powers under the EC Act 2001, the state governments have the flexibility to modify the code to suit local or regional needs and notify them. Presently, the code is in the last stage of notification.

Existing Buildings

In existing building we could save upto 30 percent of electricity by applying ecbc code. For this we could do retrofitting in the existing building and can make building close to ECBC compliant building.

The ECBC provides design norms for

- Building envelope, including thermal performance requirements for walls, roofs, and windows
- Lighting system, including day lighting, lamps and luminaries' performance requirements
- HVAC system, including energy performance of air distribution systems
- Electrical system
- Water heating and pumping systems, including requirements for solar hot-water systems.

The Conference of the Parties (COP)

It was established by the Convention as its main decision-making body. It is made up of governments and organizations such as the European Union and is responsible for guiding the Convention so that it can respond to global challenges and national needs.

COP is mandated to review reports submitted by the Parties detailing how they are carrying out their LDN commitments and make recommendations on the basis of these reports. It also has the power to make amendments to the Convention or to adopt new annexes (documents which specify how the Convention will be implemented), such as additional regional implementation annexes.

The agenda of the meetings of the Conference of the Parties is very wide-ranging, reflecting the programme of work the Conference of the Parties has established for itself. At its first meeting, the Conference of the Parties decided on a medium-term programme of work for the period 1995-1997. Implementation of this programme has laid the groundwork for the long-term implementation of the Convention itself. In particular it has seen the development of a number of thematic work programmes, and identified a series of key cross-cutting issues relevant to all work programmes.

The fourth meeting of the Conference of the Parties established a programme of work to cover the period from then until the seventh meeting and, more importantly, established a process to review the operations of the Convention and set out a longer term programme of work. As part of this process, an intersessional meeting on the operations of the Convention was held in 1999, the results of which were reported to the fifth meeting of the Conference of the Parties and formed the basis for a decision on future operations of the Convention.

End of Notes

Unit - 5
Solid Waste Management

Sources of Solid Waste

Historically, the sources of solid wastes have been consistent, dependent on sectors and activities and these include the following:

(i) Residential: This refers to wastes from dwellings, apartments, etc., and consists of leftover food, vegetable peels, plastic, clothes, ashes, etc.

(ii) Commercial: This refers to wastes consisting of leftover food, glasses, metals, ashes, etc., generated from stores, restaurants, markets, hotels, motels, auto-repair shops, medical facilities, etc.

(iii) Institutional: This mainly consists of paper, plastic, glasses, etc., generated from educational, administrative and public buildings such as schools, colleges, offices, prisons, etc.

(iv) Municipal: This includes dust, leafy matter, building debris, treatment plant residual sludge, etc., generated from various municipal activities like construction and demolition, street cleaning, landscaping, etc. (Note, however, in India municipal can typically subsume items at (i) to (iii) above).

(v) Industrial: This mainly consists of process wastes, ashes, demolition and construction wastes, hazardous wastes, etc., due to industrial activities.

(vi) Agricultural: This mainly consists of spoiled food grains and vegetables, agricultural remains, litter, etc., generated from fields, orchards, vineyards, farms, etc.

(vii) Open areas: this includes wastes from areas such as Streets, alleys, parks, vacant lots, playgrounds, beaches, highways, recreational areas, etc.

Classification of Solid Wastes

	Type	Description	Sources
Solid Wastes	Garbage	Food waste: wastes from the preparation, cooking and serving of food. Market refuse, waste from the handling, storage, and sale of produce and meat.	Households, institutions and commercial concerns such as hotels, stores, restaurants, markets, etc.
	Combustible and non–combustible	Combustible (primary organic) paper, cardboard, cartons, wood, boxes, plastic, rags, cloth, bedding, leather, rubber, grass, leaves, yard trimmings, etc.	
		Non-combustible (primary inorganic) metals, tin, cans, glass bottles, crockery, stones, etc.	
	Ashes	Residue from fires used for cooking and for heating building cinders	
	Bulky wastes	Large auto parts, tyres, stoves, refrigerators other large appliances, furniture, large crates, trees, branches, stumps, etc.	Streets, sidewalks, alleys, vacant lots, etc.
	Street wastes	Street sweepings, dirt, leaves, etc.	
	Dead animals	Dogs, cats, rats, donkeys, etc.	
	Abandoned vehicles	Automobiles and spare parts	
	Construction and demolition wastes	Roofing, and sheathing scraps, rubble, broken concrete, plaster, conduit pipe, wire, insulation, etc.	Construction and demolition sites.
	Industrial wastes	Solid wastes resulting from industry processes and manufacturing operations, such as, food processing wastes, boiler house cinders, wood, plastic and metal scraps, shavings, etc	Factories, power plants, etc.
	Hazardous wastes	Pathological wastes, explosives, radioactive materials, etc.	Households, hospitals, institutions, stores, industry, etc.
	Animal and agricultural wastes	Manure, crop residues, etc.	Livestock, farms, feedlots and agriculture
	Sewage treatment residue	Coarse screening grit, septic tank sludge, dewatered sludge.	Sewage treatment plants and septic tanks.

Solid waste management (SWM)

It is associated with the control of waste generation, its storage, collection, transfer and transport, processing and disposal in a manner that is in accordance with the best principles of public health, economics, engineering, conservation, aesthetics, public attitude and other environmental considerations.

Put differently, the SWM processes differ depending on factors such as economic status (e.g., the ratio of wealth created by the production of primary products to that derived from manufactured goods, per capita income, etc.), degree of industrialization, social development (e.g., education, literacy, healthcare, etc.) and quality of life of a location. In addition, regional, seasonal and economic differences influence the SWM processes. This, therefore, warrants management strategies that are economically viable, technically feasible and socially acceptable to carry out such of the functions as are listed

- Protection of environmental health.
- Promotion of environmental quality.
- Supporting the efficiency and productivity of the economy.
- Generation of employment and income.

SWM has socio-economic and environmental dimensions. In the socio-economic dimension, for example, it includes various phases such as waste storage, collection, transport and disposal, and the management of these phases has to be integrated. In other words, wastes have to be properly stored, collected and disposed of by co-operative management. In addition, poor management of wastes on the user side such as disposing of wastes in the streets, storm water drains, rivers and lakes has to be avoided to preserve the environment, control vector-borne diseases and ensure water quality/resource.

SWM system

A SWM system refers to a combination of various functional elements associated with the management of solid wastes. The system, when put in place, facilitates the collection and disposal of solid wastes in the community at minimal costs, while preserving public health and ensuring little or minimal adverse impact on the environment. The functional elements that constitute the system are:

(i) Waste generation: Wastes are generated at the start of any process, and thereafter, at every stage as raw materials are converted into goods for consumption, determines quantity, composition and waste characteristics. For example, wastes are generated from households, commercial areas, industries, institutions, street cleaning and other municipal services. The most important aspect of this part of the SWM system is the identification of waste.

(ii) Waste storage: Storage is a key functional element because collection of wastes never takes place at the source or at the time of their generation. The heterogeneous wastes generated in residential areas must be removed within 8 days due to shortage of storage space and presence of biodegradable material. Onsite storage is of primary importance due to aesthetic consideration, public health and economics involved. Some of the options for storage are plastic containers, conventional dustbins (of households), used oil drums, large storage bins (for institutions and commercial areas or servicing depots), etc.

(iii) Waste collection: This includes gathering of wastes and hauling them to the location, where the collection vehicle is emptied, which may be a transfer station (i.e., intermediate station where wastes from smaller vehicles are transferred to larger ones and also segregated), a processing plant or a disposal site. Collection depends on the number of containers, frequency of collection, types of collection services and routes. Typically, collection is provided under various management arrangements, ranging from municipal services to franchised services, and under various forms of contracts.

(iv) Transfer and transport: This functional element involves the transfer of wastes from smaller collection vehicles, where necessary to overcome the problem of narrow access lanes, to larger ones at transfer stations; the subsequent transport of the wastes, usually over long distances, to disposal sites.

The factors that contribute to the designing of a transfer station include the type of transfer operation, capacity, equipment, accessories and environmental requirements.

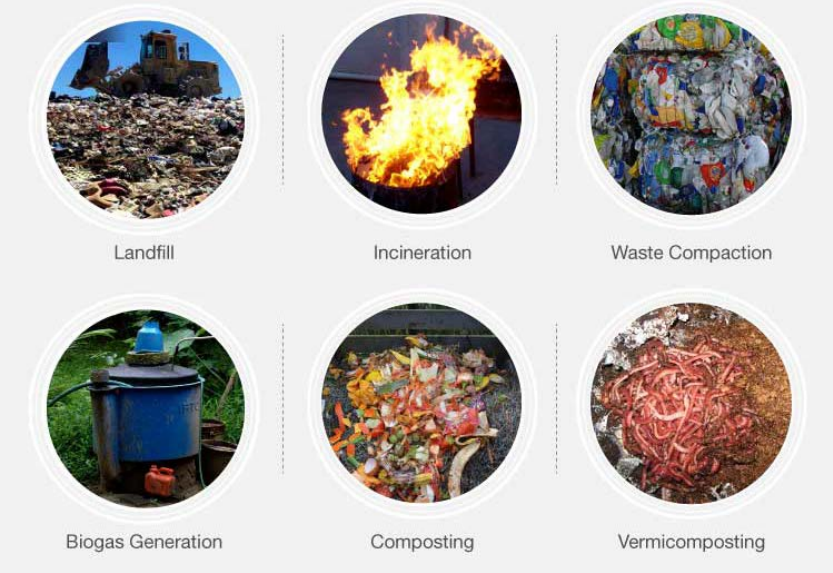
(v) Processing: Processing is required to alter the physical and chemical characteristics of wastes for energy and resource recovery and recycling. The important processing techniques include compaction, thermal volume reduction, and manual separation of waste components, incineration and composting.

(vi) Recovery and recycling: This includes various techniques, equipment and facilities used to improve both the efficiency of disposal system and recovery of usable material and energy. Recovery involves the separation of valuable resources from the mixed solid wastes, delivered at transfer stations or processing plants. It also involves size reduction and density separation by air classifier, magnetic device for iron and screens for glass. The selection of any recovery process is a function of economics, i.e., costs of separation versus the recovered-material products. Certain recovered materials like glass, plastics, paper, etc., can be recycled as they have economic value. We will discuss the various aspects of recovery and recycling, respectively, in Units 6 and 7.

(vii) Waste disposal: Disposal is the ultimate fate of all solid wastes, be they residential wastes, semi-solid wastes from municipal and industrial treatment plants, incinerator residues, composts or other substances that have no further use to the society. Thus, land use planning becomes a primary determinant in the selection, design and operation of landfill operations. A modern sanitary landfill is a method of disposing solid waste without creating a nuisance and hazard to public health. Generally, engineering principles are followed to confine the wastes to the smallest possible area, reduce them to the lowest particle volume by compaction at the site and cover them after each day's operation to reduce exposure to vermin. One of the most important functional elements of SWM, therefore, relates to the final use of the reclaimed land.

Waste Disposal Methods

Garbage accumulation has never been much of a concern in the past, but due to globalization and industrialization, there is a need for a more efficient waste disposal method. Following are some of the methods that are used today.



Open Dumping

- An open dumping site is one where solid waste is disposed of in a way that does not safeguard the environment, is subject to open burning, and is exposed to the elements, vectors, and scavengers.
- Although some open dumps are cleared soon after they are made, most will remain for an indefinite period of time if the location is positioned in the wilderness or in a public space with insufficient public services.

- The discharge of toxic pollutants and heavy metals into the air and water, the increased presence of disease vectors such as rodents and insects, and physical risks such as hypodermic needles, noxious fumes, and/or piercing objects are all potential hazards of open dumping.
- The open dumps are also used in the energy-generating sector
- Carbon dioxide and methane are created when waste accumulates and begins to decompose. These gases can be extracted, purified, and used to generate energy.
- An officially designated municipal solid waste landfill or sanitary waste landfill is not an open dump.

Landfill

In this process, the waste that cannot be reused or recycled are separated out and spread as a thin layer in low-lying areas across a city. A layer of soil is added after each layer of garbage. However, once this process is complete, the area is declared unfit for construction of buildings for the next 20 years. Instead, it can only be used as a playground or a park.

Incineration

Incineration is the process of controlled combustion of garbage to reduce it to incombustible matter such as ash and waste gas. The exhaust gases from this process may be toxic, hence it is treated before being released into the environment. This process reduces the volume of waste by 90 per cent and is considered as one of the most hygienic methods of waste disposal. In some cases, the heat generated is used to produce electricity. However, some consider this process, not quite environmentally friendly due to the generation of greenhouse gases such as carbon dioxide and carbon monoxide.

Composting

All organic materials decompose with time. Food scraps, yard waste, etc., make up for one of the major organic wastes we throw every day. The process of composting starts with these organic wastes being buried under layers of soil and then, are left to decay under the action of microorganisms such as bacteria and fungi.

This results in the formation of nutrient-rich manure. Also, this process ensures that the nutrients are replenished in the soil. Besides enriching the soil, composting also increases the water retention capacity. In agriculture, it is the best alternative to chemical fertilizers.

Vermicomposting

Vermicomposting is the process of using worms for the degradation of organic matter into nutrient-rich manure. Worms consume and digest the organic matter. The by-products of digestion which are excreted out by the worms make the soil nutrient-rich, thus enhancing the growth of bacteria and fungi. It is also far more effective than traditional composting.

Recycling and Recovery of Solid Waste

Recycling is the recovery and reuse of materials from wastes. Solid waste recycling refers to the reuse of manufactured goods from which resources such as steel, copper, or plastics can be recovered and reused. Recycling and recovery is only one phase of an integrated approach to solid waste management that also includes reducing the amount of waste produced, composting, incinerating, and landfilling.

Municipal solid waste (MSW) comes from household, commercial, institutional, and light industrial sources, and from some hospital and laboratory sources. In 2000 the United States produces nearly 232 million tons (210.5 million metric tons) of MSW per year, almost 4.5 lb (2 kg) per resident per day. The percentages of MSW generated in this country include paper and paperboard, 38.1%; yard wastes, 12.1%; metals, 7.8%; glass, 5.5%; rubber , textiles, leather and wood, 11.9%; food wastes, 10.9%; plastics, 10.5%; and other, 3.2%.

Recycling is a significant way to keep large amounts of solid waste out of landfills, conserve resources, and save energy. As of 2000, Americans recovered, recycled, or composted 30.1% of MSW, incinerated 14.5%, and landfilled 55.3%.

The technology of recycling involves collection, separation, preparing the material to buyer's specifications, sale to markets, processing, and the eventual reuse of materials. Separation and collection is only the first step; if the material is not also processed and returned to commerce, then it is not being recycled. In many parts of the country, markets are not yet sufficiently developed to handle the growing supply of collected material.
Intermediate markets for recyclable materials include scrap dealers or brokers, who wait for favorable market conditions in which to sell their inventory. Final markets are facilities where recycled materials are converted to new products, the last phase in the recycling circle.

Health impacts
Due to the absence of standards and norms for handling municipal wastes, municipal workers suffer occupational health hazards of waste handling. At the dumpsites in the city of Mumbai, for example, 95 workers were examined and it was found that about 80% of them had eye problems, 73% respiratory ailments, 51% gastrointestinal ailments and 27% skin lesions. Also, municipal workers and rag pickers who operate informally for long hours rummaging through waste also suffer from similar occupational health diseases ranging from respiratory illnesses (from ingesting particulates and bio-aerosols), infections (direct contact with contaminated material), puncture wounds (leading to tetanus, hepatitis and HIV infection) to headaches and nausea, etc. Studies among the 180 rag pickers at open dumps of Kolkata city reveal that average quarterly incidence of diarrhoea was 85%, fever 72% and cough and cold 63%.

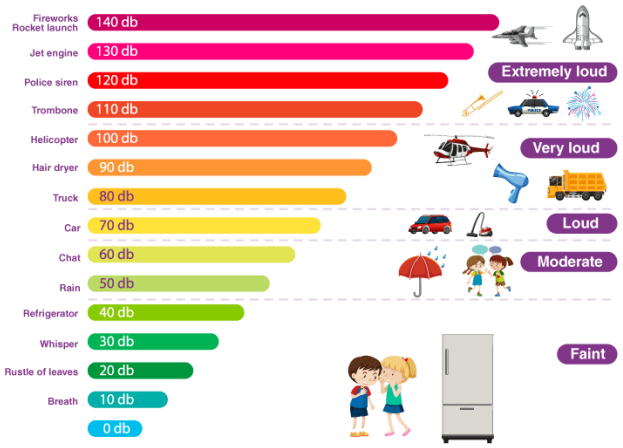
Environmental impacts
In addition to occupational health, injury issues and environmental health also need to be mentioned in the context of waste management. Contaminated leachate and surface run-off from land disposal facilities affects ground and surface water quality. Volatile organic compounds and dioxins in air-emissions are attributed to increasing cancer incidence and psychological stress for those living near incinerators or land disposal facilities. Drain clogging due to uncollected wastes leading to stagnant waters and subsequent mosquito vector breeding are a few of the environmental health issues, which affect the waste workers as well as the public. The pneumonic plague that broke out in November 1994 in India (Surat, Gujarat) is a typical example of solid waste mismanagement.

Noise Pollution

The word noise is derived from the Latin word ‘Nausea’, which means sickness in which one feels the need to vomit. Noise is the unpleasant and undesirable sound which leads to discomfort in human beings. The intensity of sound is measured in decibels (dB). The faintest sound that the human ear can hear is 1 Db. Due to increasing noise around the civilizations; noise pollution has become a matter of concern. Some of its major causes are vehicles, aircraft, industrial machines, loudspeakers, crackers, etc. When used at high volume, some other appliances also contribute to noise pollution, like television, transistor, radio, etc.

Types of Noise Pollution
Following are the three types of pollution:

- Transport Noise
- Neighborhood Noise
- Industrial Noise



Transport Noise
It mainly consists of traffic noise which has increased in recent years with the increase in the number of vehicles. The increase in noise pollution leads to deafening of older people, headache, hypertension, etc.

Neighbourhood Noise
The noise from gadgets, household utensils etc. Some of the main sources are musical instruments, transistors, loudspeakers, etc.

Industrial Noise
It is the high-intensity sound which is caused by heavy industrial machines. According to many researches, industrial noise pollution damages the hearing ability to around 20%.

Causes and Sources of Noise Pollution
Following are the causes and sources of noise pollution:

- Industrialization: Industrialization has led to an increase in noise pollution as the use of heavy machinery such as generators, mills, huge exhaust fans are used, resulting in the production of unwanted noise.
- Vehicles: Increased number of vehicles on the roads is the second reason for noise pollution.
- Events: Weddings, public gatherings involve loudspeakers to play music resulting in the production of unwanted noise in the neighborhood.
- Construction sites: Mining, construction of buildings, etc. add to the noise pollution.

Noise Pollution Examples
Following are the examples of noise pollution:

- Unnecessary usage of horns
- Using loudspeakers either for religious functions or for political purposes
- Unnecessary usage of fireworks
- Industrial noise
- Construction noise
- Noise from transportation such as railway and aircraft

Effects of Noise Pollution on Human Health
Noise pollution can be hazardous to human health in the following ways:

- Hypertension: It is a direct result of noise pollution which is caused due to elevated blood levels for a longer duration.
- Hearing loss: Constant exposure of human ears to loud noise that are beyond the range of sound that human ears can withstand damages the eardrums, resulting in loss of hearing.
- Sleeping disorders: Lack of sleep might result in fatigue and low energy level throughout the day affecting everyday activities. Noise pollution hampers the sleep cycles leading to irritation and an uncomfortable state of mind.
- Cardiovascular issues: Heart-related problems such as blood pressure level, stress and cardiovascular diseases might come up in a normal person and a person suffering from any of these diseases might feel a sudden shoot up in the level.

Prevention of Noise Pollution
Some noise pollution preventive measures are provided in the points below.

- Honking in public places like teaching institutes, hospitals, etc. should be banned.
- In commercial, hospital, and industrial buildings, adequate soundproof systems should be installed.
- Musical instruments' sound should be controlled to desirable limits.
- Dense tree cover is useful in noise pollution prevention.
- Explosives should not be used in forest, mountainous and mining areas.

Controlling Devices

Eco Barriers

Eco barriers are industrial sound control product, and its features are as follow:

- Exceptional sound performance can reduce the noise up to 10-20dB and more if the facing is doubled
- Easy to handle, lightweight and durable
- The facing can be doubled or tripled according to the requirement of the industry
- Weather and fire resistant
- Can be installed easily
- Reusable and can be used as indoor and outdoor fencing.

Soundproof Interior Doors

Soundproof interior doors are available for reducing noise pollution in any specific area and not disturbing the entire site. Salient features of soundproof doors are as follows:

- Soundproof doors are low cost and give high performance.
- These can be customized to any size and color that is ready to stain.
- Mostly it is in oak color and can be colored according to the interior, optional are maple, birch, cherry or any other desired wood
- Standard hardware color is satin chrome while other colors can be made available.
- Ideal for studios, music rooms, conference rooms or office etc
- Can reduce the noise pollution effectively

Soundproof Interior Windows

Soundproof windows are also available that can efficiently reduce noise pollution. Its characteristics are as follows:

- They can be installed in variety of environments and projects
- They are durable and shock resistant
- They are widely used in military, interrogation rooms, studios, music rooms etc
- Excellent noise reduction is observed
- It can be engineered on demand and can be made of any size.
- Material used in soundproof windows is anodized aluminum frame and frame finishes are of natural aluminum or bronze.
- Easy to install and handle

Ceiling Baffles

Ceiling baffles are the devices that are hung down the ceiling of the building to reduce the resonance or echo produced. The characteristics of ceiling baffles are:

- Effective and cost effective in negating noise of the area
- These are the devices hung down the ceiling to absorb any amplified noise and reduce resonance and echo.
- These baffles are economical and can be installed in areas with low space
- They work by bouncing off the sound and reducing it in return.
- Ceiling baffles also provide speech clarity
- There are two types of ceiling baffles that are poly baffles and quilted fiberglass baffles
- These are made of fiberglass with sharp edges, and all faces and edges are covered with fabric
- Standard size is up to 4’×10’
- Standard thickness is of 2” and 4”
- Edges are of different shapes such as square, bevel, radius, pencil, and miter
- These ceiling baffles are mostly used in areas where a pleasant look is also required
- They can be used in the gymnasium, lobbies, receptions, offices, conference rooms, auditorium, theaters, libraries, etc.

Acoustic Foams

Acoustic foams absorb the airborne sound waves and thus reduce noise pollution of the area. Acoustic foams can be applied on the ceiling, doors and walls of the room which helps reduce the sound of low to mid frequency. These acoustic foams are flexible in structure and when a sound wave is entered into its composition, it is absorbed and reduced drastically. Acoustic foams can be found in two shapes, flat shaped or convoluted shape. They can be placed parallel on the surface or in egg crate shape. There are three different types of acoustic foams:

Mineral Wool

Mineral wool is made from inorganic mineral fibers enhanced with glass fibers with a sound transmission class (STC) of 10, which means that it provides a high level of sound reduction and noise control. It is made from several different minerals including polycrystalline and silicate. Mineral wool is made from molten rock that is passed through a stream of air or steam. More advanced processes, spin the molten rock to produce the rock fibers.

Rockwool

Rockwool is stone wool insulation able to withstand temperatures of 2150 oF with exceptional acoustical dampening properties

Properties of Rockwool:

- Easy to cut and shape
- Non-combustible
- High sound absorbency
- Fire-resistant
- Resists rot and prevents the growth of fungi and bacteria
- Resistant to water and moisture resistant

Air Duct Silencers

Air duct silencers, also known as sound attenuators, are designed to control noise in ducts, building openings, enclosures, and equipment. The various forms of silencers include acoustical silencers, generator and engine silencers, HVAC silencers, and sound traps that reduce sound volume from a factory floor.

When thin sheets of metal in a duct system expands, it makes popping and banging sounds. Systems can also make noise if they have not been cleaned or are undersized. To suppress the noise, silencers are installed near the source of the noise such as fans, air handling units, air flow regulators, or fire and air dampers.

Sound Dampening

Sound dampening reduces the volume of sound by increasing the distance from the sound, installing dampening structures, and using anti-noise devices.

Noise Barriers

Noise barriers are structures used to trap sound and keep it from interfering with the outside environments. On roads, “noise walls” are used to reduce the sounds of busy roads. Noise barriers are an effective low tech noise suppression system that significantly reduces the effects of noise pollution.

Dampening Structures

Dampening structures reduce sound reflected by surfaces using soft materials such as foam or fabric. Irregularly designed panels known as sound baffles have a number of flat surfaces that are almost perpendicular to the wall. They are designed to reflect the sound off of each other multiple times. With each reflection, sound is reduced. The use of baffles, when combined with foam, has a dramatic effect on noise suppression.

Anti-Noise Cancellation
ANC is a form of sound dampening and can be used for larger areas with the installation of microphones and speakers. When the ANC sound waves combine with intrusive sound, the two sets of waves cancel each other.

Acoustic Enclosures
In industry production sites, there is a lot of resonance and reflection of sound, which becomes difficult to handle and work in such a noisy environment. For this purpose, acoustic enclosures are there to help. These enclosures reduce industrial noise pollution with the help of a metal case that is formed outside the machinery. This reduces the noise and helps in smooth working. The key features of these enclosures are as follows:

- Can be used for indoor as well as outdoor units.
- For combustion there is an air inlet drive.
- From 15dB A to 50dBA+ noise reduction.
- It has lightning, a firefighters system, and air conditioning.
- For combustion engines there is an exhaust gas removal.

Varitone Sound Absorption System
Varitone sound absorption panels are rectangular and are attached to the walls or hang down the ceiling of an enclosed or semi enclosed area. They are highly compatible in reducing the echo or resonance produced inside any building by dispersing it inside and creating a softer tone to improve audio and visual communication. These varitone panels are made up of perforated steel, and inside their walls there are acoustic absorbents present, making them highly effective to use in areas like schools, sport halls, or music rooms. Additionally these panels can be cleaned easily and thus very useful in food facilities. Varitone absorption panels are finished with galvanized steel and polyester powder coating.
Applications:

- Schools
- Auditorium
- Airports
- Music practice rooms
- Conference halls
- Restaurants
- Prison cells
- Gymnasium
- Test centers
- Swimming pools

End