

## **Unit-1 INTRODUCTION TO ENVIRONMENT**

Environment is a complex of many variables, which surrounds man as well as the living organisms. Environmental studies describe the interrelationships among organisms, the environment and all the factors, which influence life on earth, including atmospheric conditions, food chains, the water cycle, etc.

It is a basic science about our earth and its daily activities, and therefore, this science is important for one and all.

### **Scope of environmental studies**

1. The study creates **awareness** among the people to know about various **renewable and non-renewable resources** of the region. The endowment or potential, patterns of utilization and the balance of various resources available for future use in the state of a country are analysed in the study.
2. It provides the **knowledge about ecological systems** and cause and effect relationships.
3. It provides necessary **information about biodiversity richness** and the potential dangers to the species of plants, animals and microorganisms in the environment.
4. The study enables one to understand the **causes and consequences due to natural and main induced disasters** (flood, earthquake, landslide, cyclones etc.,) and pollutions and measures to minimize the effects.
5. It enables one to **evaluate alternative responses to environmental issues** before deciding an alternative course of action.
6. The study enables environmentally **literate citizens** (by knowing the environmental acts, rights, rules, legislations, etc.) to make appropriate judgments and decisions for the protection and improvement of the earth.
7. The study exposes the problems of over population, health, hygiene, etc. and the role of arts, science and technology in eliminating/ minimizing the evils from the society.
8. The study tries to identify and develop appropriate and indigenous eco-friendly skills and technologies to various environmental issues.

9. It teaches the citizens the need for **sustainable utilization** of resources as these resources are inherited from our ancestors to the younger generation without deteriorating their quality.

10. The study enables theoretical knowledge into practice and the multiple uses of environment.

### **Importance of environmental study**

Environmental study aims to make the citizens competent to do scientific work and to find out practical solutions to current environmental problems.

The citizens acquire the ability to analyze the environmental parameters like the aquatic, terrestrial and atmospheric systems and their interactions with the biosphere and anthrosphere.

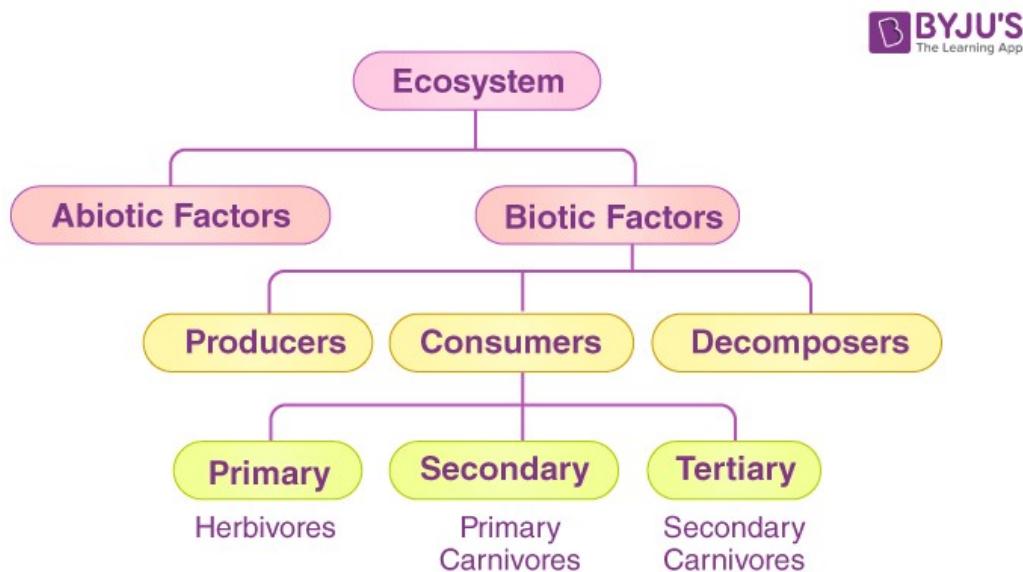
- The people should take a combined responsibility for the deteriorating environment and begin to take appropriate actions to save the earth.
- Education and training are needed to save the biodiversity and species extinction.
- The urban area, coupled with industries, is major sources of pollution.
- The study enables the people to understand the complexities of the environment and need for the people to adapt appropriate activities and pursue sustainable development, which are harmonious with the environment.
- The study motivates students to get involved in community action, and to participate in various environmental and management projects.
- Environmental studies take a multidisciplinary approach to the study of human interactions with the natural environment. It integrates different approaches of the humanities, social sciences, biological sciences and physical sciences and applies these approaches to investigate environmental concerns.

## 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 characterised by the organisation 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**.



## Biotic Components

Biotic components refer to all living components in an ecosystem. **Based on nutrition**, biotic components can be categorised 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 utilisation 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**

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.

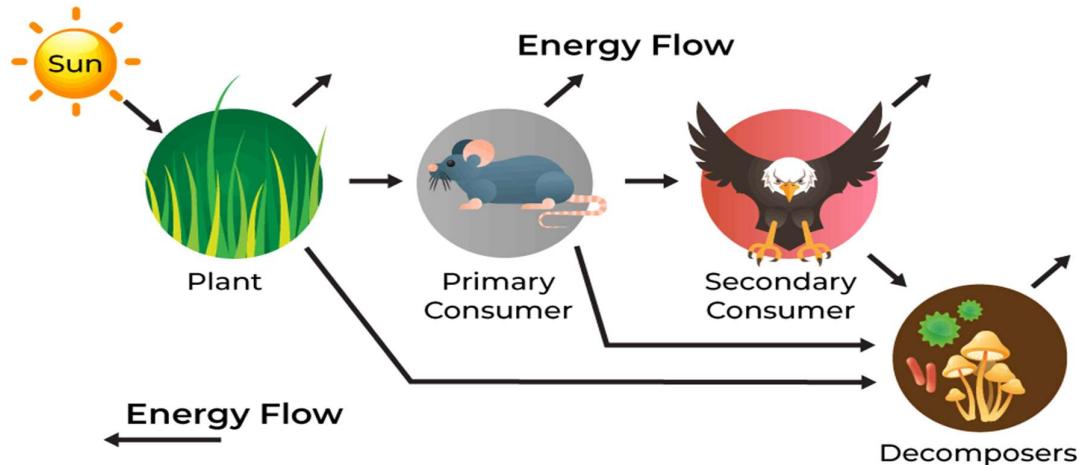
### **Marine Ecosystem**

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

## **Energy Flow in Ecosystem**

- The energy flow of an ecosystem means the pathway energy takes to move from one organism to another in an ecosystem. The energy flow of an ecosystem is a fundamental concept of ecological studies.
- The energy flow of an ecosystem is unidirectional and is typically in the form of food flow from one trophic level to another.
- The energy flow of the ecosystem harnesses the energy that cascades through the food chain and food webs.
- The energy flow of the ecosystem helps us to understand how different species of various trophic levels interact with each other.
- Energy flow is the phenomenon that is responsible to sustain life on this planet.

- All the biotic components in this ecosystem need energy for their survival. If the energy flow in an ecosystem is disturbed, then it leads to ecological imbalance.
- This energy flow occurs on the Earth through the biogeochemical cycle.



## Laws of Thermodynamics in Ecosystem

### First Law of thermodynamics

It states that energy can neither be created nor destroyed, but it keeps changing from one form to the other. Similarly in an ecosystem, the main source of energy is the sun, and this energy from the sun is transferred from one level to the other.

### Second Law of thermodynamics

It states that when energy transforms from one form to another, some part of it is lost as heat to the surroundings. Thus the energy at one level is never completely transferred to the other.

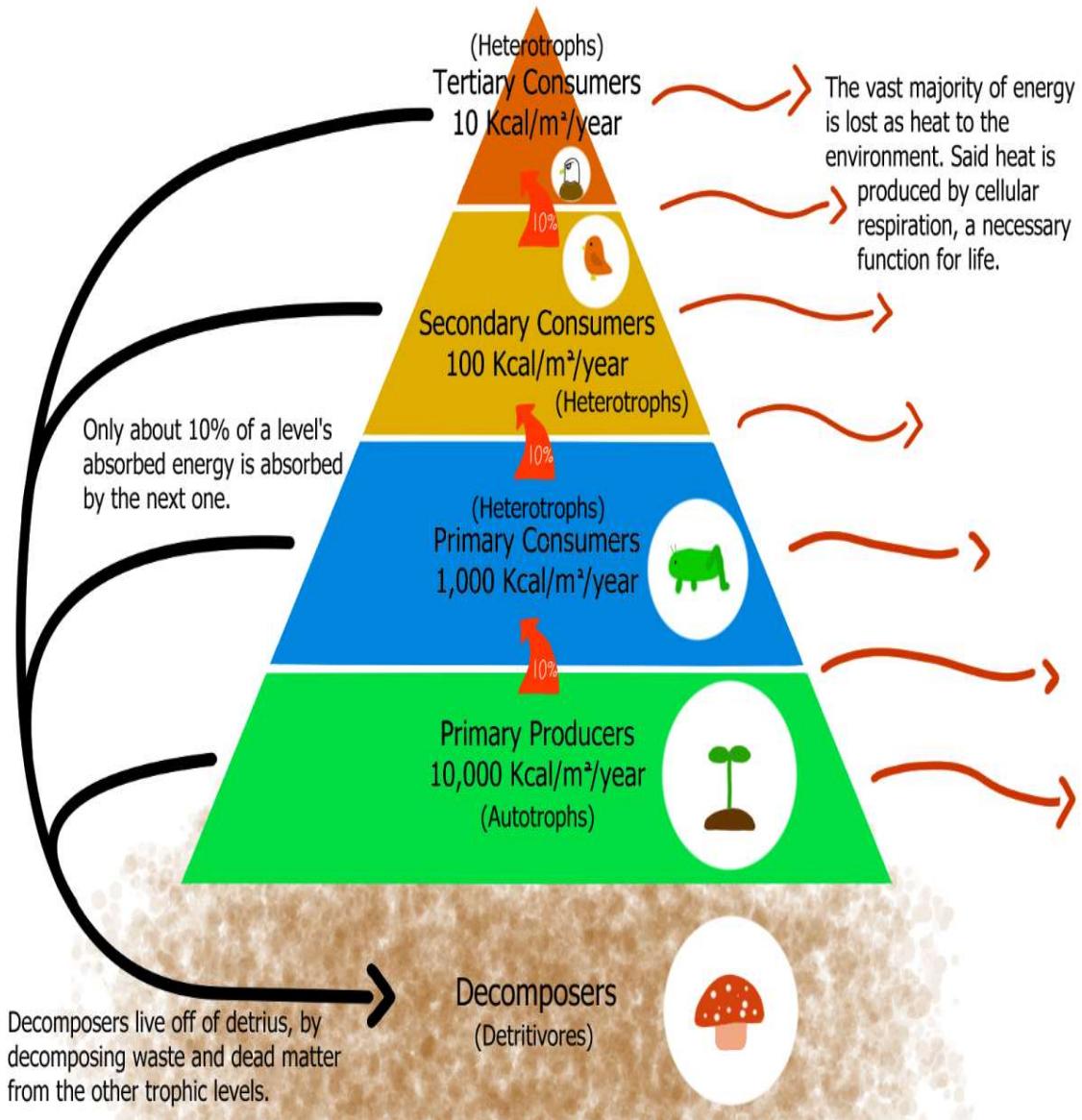
### Direction of Energy Flow

- The direction of the energy flow in an ecosystem is unidirectional. It flows from the primary source of energy i.e. the sun's light energy to producers or autotrophs which then transferred to the consumers.
- The producer uses the solar energy to produce organic food which flows through a series of trophic levels.
- Each trophic level captures a portion of this energy for its metabolic needs, while the rest is passed to the next level.
- The flow of energy follows the following pathway;

Solar Energy → Producer (autotrophs) → Consumer (herbivores) →  
Consumer (carnivores) → Consumer (higher levels of carnivores)

## Trophic Levels & Energy Transfer

Trophic levels are split by a who-eats-who system.





In the above food chain:

1. In the first stage, plants are eaten by herbivores such as grasshoppers.
2. Then herbivores such as deer are consumed by carnivores such as lions, tigers, etc.
3. On the death of carnivores, they are consumed by scavengers such as eagles and vultures.
4. When vultures die, their bodies are broken down by bacteria and fungi to nutrients.
5. These nutrients are again used by the plants for their growth.

### **Significance of Energy Flow in Ecosystem**

Following are some of the significances of Energy Flow in an Ecosystem;

1. It is vital for all living things in ecosystem to survive and function properly.
2. It helps us to understand who eats whom in nature.
3. It helps us to see how human action are affecting the ecosystem.
4. It shows how all creatures in an ecosystem depend on each other and how changes can affect each other.

## **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.

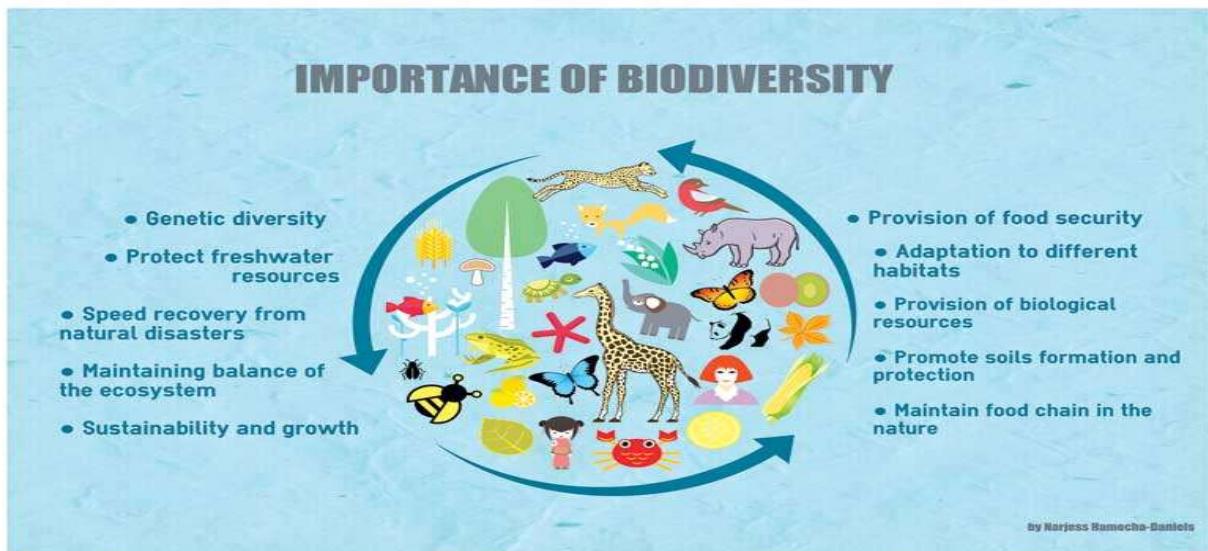
Crops, livestock, fishery, and forests are a rich source of food.

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.



## THREATS TO BIODIVERSITY

Though the rate of loss of species has been a slow process in the past, the process of extinction has become fast in recent years. It has been reported that approximately 10,000 species become extinct every year. This raises an alarm regarding the threat to biodiversity. If this trend continues 1/3 or 2/3 of our current biodiversity would become extinct by the middle of the 21st century.

Factors causing loss of biodiversity

### • Loss of Habitat

- Destruction of habitats due to clearing of forests and grasslands for agricultural lands, pastures, settlement areas or project development leads to loss of habitat. These factors are responsible for the disappearance of thousands of species.
- The wetlands, mangroves and estuaries with rich biodiversity are under threat. They are destroyed, as if they have no value.

### • Poaching of wild life

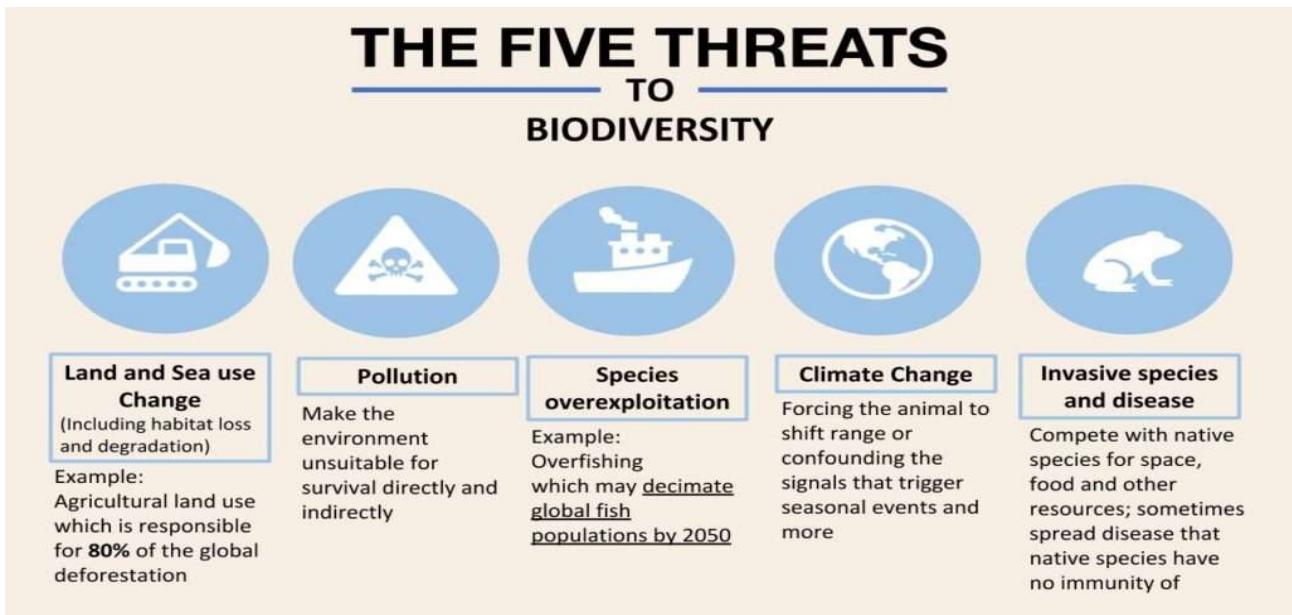
The illegal commercial hunting is called poaching. There are two types of hunting.

- I) subsistence hunting (killing animals for food) and
- II) sport hunting (killing animals to sell their meat, fur, horns, tusks etc.)

### • Man-Animal conflicts

Sometimes, wild animals threaten human beings. This leads to conflict between wild life and man.

- When the habitats of wild animal are destroyed by man, the animals are forced to come out of the forest in search of food to the nearby human settlements and attack human beings when they come in contact with them accidentally.
- The weak and injured animals have a tendency to attack man. A tigress attacks man in order to protect its cubs. Once a tiger tastes the flesh of a man accidentally, it becomes a man-eater.
- When wildlife corridors are converted into human settlements, the path of wild life is disrupted and animals attack the settlements.



### Conservation of Biodiversity

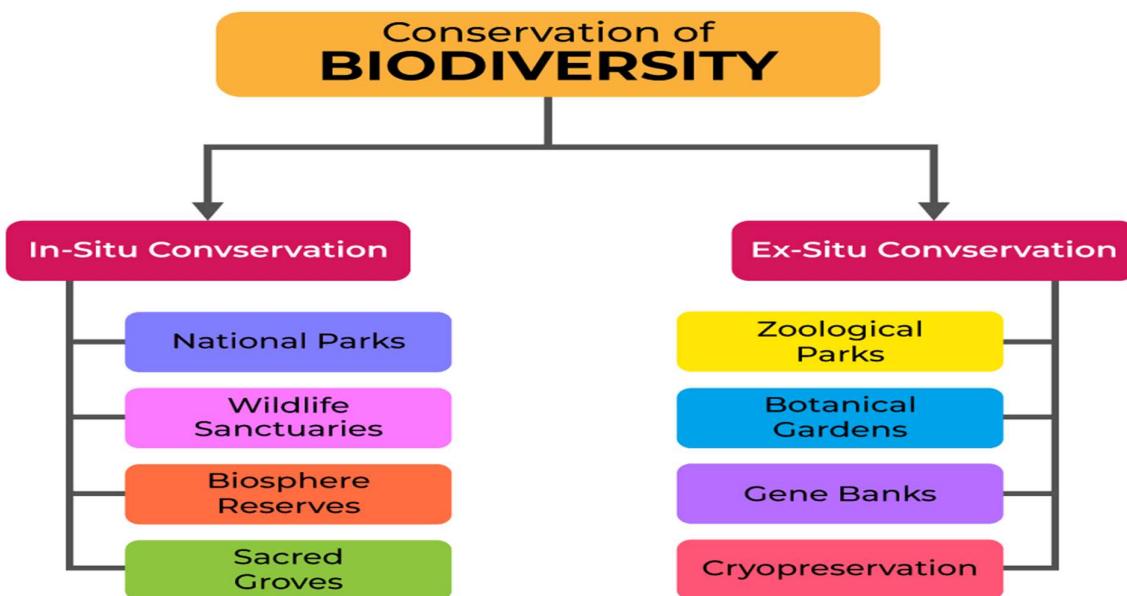
Conservation is defined as 'the management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generation while maintaining its potential to meet the needs and aspirations of future generations'. Conservation of our natural resources has the following three specific objectives:

1. To maintain essential ecological processes and life-supporting systems.
  2. To preserve the diversity of species or the range of genetic material found in the organisms on the planet, and
  3. To ensure sustainable utilization of species and ecosystems which support millions of rural communities as well as the major industries all over the world.
- The wildlife conservation efforts are mostly centred on protecting plant and animal life in protected habitats, such as – botanical gardens, zoos, sanctuaries, national parks, biosphere reserves, etc.

## Methods of Conservation

There are two methods of conservation of biodiversity.

- In-situ conservation (within habitat)
- Ex-situ conservation (outside habitats)



### In-situ conservation

- In-situ or on-situ conservation means conservation of species in its natural ecosystem or even in man-made ecosystems (i.e. artificial ecosystems).
- This type of conservation applies only to wild fauna and flora, and not to the domesticated animals and plants because conservation is possible by protection of population in nature.
- In-situ conservation is a “protected area” ( an area of land and/ or sea specially dedicated to the protection and maintenance of biological diversity and of natural and associated cultural resources and managed through legal or other effective means) , which involves setting aside large portions of earth’s surface for wildlife with emphasis either to save the entire area or an endangered species.
- There are different categories of protected areas which are managed with different objective. These include – national parks, sanctuaries, biosphere reserves, etc.

The advantages of In-situ conservation are:

- In-situ conservation is the best strategy for the long term protection of biodiversity.

- Large pockets/ areas of protected zones are essential for not only conserving vast number of species of living organisms but also provide opportunities to evolve. Otherwise, man-made habitats (e.g. zoo, aquarium, etc.) may end-up with static gene-pool.
- in-situ is cheaper to protect populations in their natural habitat than to reintroduce captive-bred ones.

### **Ex-situ conservation**

- Ex-situ conservation means conservation of species (sample of genetic diversity), particularly of endangered species, away from their natural habitat under human supervision.
- In-situ conservation is the best strategy for the long-term protection of biodiversity; however, for many rare species or species having small remaining population, it is not a viable option in the light of increasing human disturbances.
- Further, species may decline and go extinct in the wild due to genetic drift and inbreeding, environmental and demographic variation, deteriorating habitat quality, competition from exotic species, disease or over-exploitation.
- Under such circumstances, the only possible way a species can be prevented from going extinct is to maintain individuals in artificial conditions under human care.
- In ex-situ conservation, the endangered species of animals are collected and bred under controlled conditions in zoos, game farms, aquaria, etc., while plant species are maintained in botanical gardens, arboreta and seed banks.

The advantages of ex-situ conservation are:

- The organism is assured of food, shelter and security, and hence can have longer life-span and breeding activity. Thus, increasing the possibility of having a greater number of off springs.
- Under human care and secure conditions, the chances of survival increase.
- Ex-situ conservation also provides the possibility of using genetic techniques to improve the concerned species.
- Captive breeding can provide animals for possible reintroduction to the wild at a later stage or for supplementing current populations with new stock.

Limitations and disadvantages of ex-situ conservation:

- Ex-situ conservation can be adopted only for a few selected species because of limitations of space, finances and facilities in the institutions that undertake captive breeding.

- Ex-situ conservation, under a set of favourable environmental conditions, deprives the organism the opportunity to adapt to the ever-changing natural environment. As a result, new life-forms cannot evolve and the gene-pool gets stagnant.

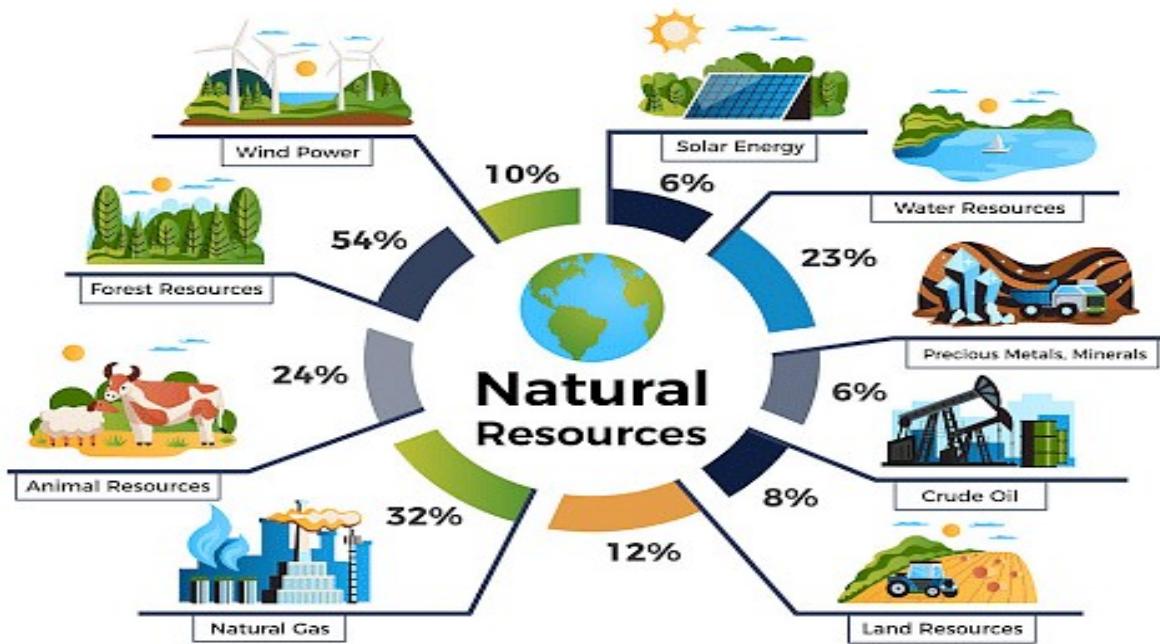
Following are the important strategies for biodiversity conservation:

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 the resources that exist without any actions or intervention of human beings in nature. People cannot make natural resources; however, they can collect them.

It consists of water, sunlight, atmosphere, land including all minerals along with all the vegetation, crops, and animal life that naturally subsists on or within these known and identified substances and characteristics.



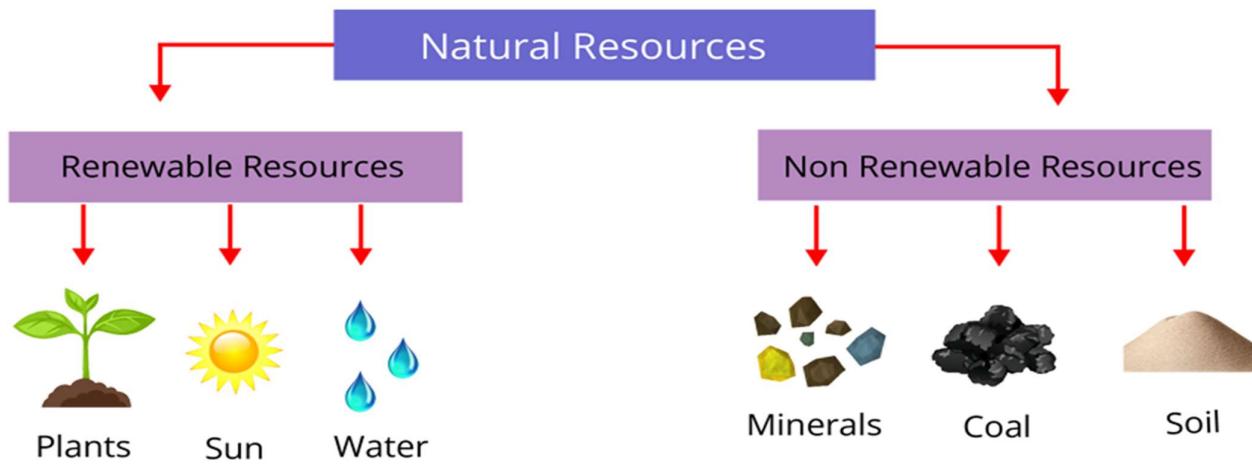
There are several problems that are attached to natural resources.

1. The irrational consumption and overuse of these natural resources have led to several socio-economic and environmental problems.
2. Natural resources are available in a fixed quantity and are non-renewable.
3. There is an increasing scarcity of these natural resources as the population is increasing day by day.
4. Non-renewable natural resources take millions of years to form.
5. Planning land use as a major resource, needed for not only for food production and animal husbandry, but also for industry and growing human settlements. These forms of intensive land use are frequently extended at the cost of 'wild lands', our remaining forests, grasslands, wetlands and deserts.
6. The need for sustainable lifestyles, Human standard of living and the health of the ecosystem are indicators of sustainable use of resources in any country or region. Ironically, both are not in concurrence with each other. Increasing the level of one, usually leads to degradation of other. Development policies should be formulated to strike a balance between the two.

### **Classifications of Natural Resources**

Depending upon availability of natural resources can be divided into two categories:

1. Renewable natural resources and
2. Non-renewable natural resources



**Renewable natural resources** are the resources that can be generated again once they are used. Renewable resources are in a way inexhaustible resources. They have the ability to replenish themselves by means such as recycling, reproduction and replacement.

Examples of renewable resources are sunlight, animals and plants, soil, water, etc.

**Non-renewable natural resources** are the ones that exhaust after their frequent usage and sometimes it takes a really long time for them to regenerate. The resources that cannot be replenished once used or perished. An example of this includes natural gas, coal, minerals, fossil fuels, etc.

### Natural Resources and their Conservation

It is highly important that we conserve these natural resources since they are getting exhausted at an alarming rate. Apart from that, it has an adverse effect on the environment that is indirectly causing harm to living beings. However, if we follow some tips in our day to day lives, we can conserve these natural resources.

1. Use an alternative source of power like solar and wind energy
2. Plant more trees for preventing the soil erosion
3. Use pipelines for transporting oil
4. Treat the industrial sewage and wastage even before they get released into the water bodies
5. Include the rainwater harvesting system in the house
6. Use biogas in the house

7. Use biofuels instead of the conventional petroleum-based fuels
8. Ensure that the wastes are being recycled
9. Use electronic mails
10. Make use of the energy-saving tube lights and bulbs
11. Practice the method of crop rotation
12. Construct reservoirs

## **Forest**

Forests are complex land ecosystems that support a wide variety of plants, trees and animals. It provides a lot of resources like fruits, timber, firewood, honey, herbal medicines etc. The forests also provide several raw materials for different manufacturing industries.

### **Forest Resources**

Forest is important renewable resources. Forest vary in composition and diversity and can contribute substantially to the economic development of any country. Plants along with trees cover large areas, produce variety of products and provide food for living organisms, and also important to save the environment.

### **Significance of forests**

Forest can provide prosperity of human being and to the nations. Important uses of forest can be classified as under

- Commercial values
- Ecological significance
- Aesthetic values
- Life and economy of tribal

### **Commercial values**

• Forests are main source of many commercial products such as wood, timber, pulpwood etc. About 1.5 billion people depend upon fuel wood as an energy source. Timber obtained from the forest can used to make plywood, board, doors and

windows, furniture, and agriculture implements and sports goods. Timber is also a raw material for preparation of paper, rayon and film.

- Forest can provide food, fibre, edible oils and drugs.
- Forest lands are also used for agriculture and grazing.
- Forest is important source of development of dams, recreation and mining.

### **Life and economy of tribal**

Forest provides food, medicine and other products needed for tribal people and play a vital role in the life and economy of tribes living in the forest.

### **Ecological uses**

Forests are habitat to all wild animals, plants and support millions of species. They help in reducing global warming caused by greenhouse gases and produces oxygen upon photosynthesis.

Forest can act as pollution purifier by absorbing toxic gases. Forest not only helps in soil conservation but also helps to regulate the hydrological cycle.

### **Aesthetic values**

All over the world people appreciate the beauty and tranquillity of the forest because forests have a greatest aesthetic value. Forest provides opportunity for recreation and ecosystem research.

### **Deforestation**

1. Forest are burned or cut for clearing of land for agriculture, harvesting for wood and timber, development and expansion of cities .These economic gains are short term where as long term effects of deforestation are irreversible
2. Deforestation rate is relatively low in temperate countries than in tropics If present rate of deforestation continues, we may losses 90% tropical forest in coming six decades

### **Effects of deforestation**

Deforestation adversely and directly affects and damages the environment and living beings. Major causes of deforestation are

- Soil erosion and loss of soil fertility
- Decrease of rain fall due to effect of hydrological cycle
- Expansion of deserts
- Climate change and depletion of water table
- Loss of biodiversity ,flora and fauna

- Environmental changes and disturbance in forest ecosystems

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### Consequences of Deforestation



Global Warming



Pollution



Drought



Desertification



Animal & Plant Life Affected



Shortage of food



Flooding of Rivers

## WATER RESOURCES

Water is a very important source and essential for life because it has very unique characteristic. It is the natural resource. There is an uneven distribution of water resources, tropical rain forest are receiving maximum rainfall where as desert receive only little rainfall.

Due to its unique properties water is of multiple uses for all living organisms. Water is absolutely essential for all the living organisms. One can survive for weeks without food but cannot survive more than a few days without water. Since the earliest days of mankind water availability was the major factor to decide the place of human settlements. Water dissolves nutrients and distributes them in different parts of plants and regulates the temperature and removes the waste.

Water is the universal solvent and plays a key role in the existence of various forms of life on the planet earth. It is widely used for various purposes such as washing, bathing, cleaning, cooking, drinking, and other industrial and domestic uses.

There are various sources of water such as wells, rivers, ponds, lakes, oceans, big dams, and streams. As we all know, nearly 70 to 80 percent of the Earth's surface is covered by water, among which only 1-2 per cent water is pure and suitable for human use.

## **Uses of Water**

- The hydrological system forms rivers and lakes and support in a variety of aquatic ecosystems.
- All aquatic ecosystems (well, lake, pond, river, etc.,) are used by a large number of people for their daily needs such as, drinking water, washing, cooking, watering animals, and irrigating fields.
- Many agriculturists use water to grow crops.
- Industries uses water their productivity.
- Paper industries use water for manufacturing paper.

## **Conservation of water**

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. Conservation of water is very much essential as it saves life on earth.

- Keeping the tap closed when not in use.
- Check for the openings or leaks in water distribution pipes.
- Make sure to use collected rainwater for gardening or washing purpose.
- Do not run more water than necessary while washing and cleaning clothes, utensils, etc.
- Do not prolong your bathing. Go for a quick shower rather than wasting buckets of water
- Rainwater harvesting is one of the best methods used for conserving water. There are different methods used to preserve rainwater instead of getting it wasted.

## **Mineral Resources**

- A mineral is a naturally occurring substance, representable by a chemical formula, that is usually solid and inorganic, and has a crystal structure.

- Minerals are essential for the formation and functioning of organisms, plant animals and human beings.

### **Environmental Impacts of Mineral Extraction**

Extracting and use of mineral resources can affect the environment adversely.

Environmental affect may depend on factors such as mining procedures, ore quality, climate, size of operation, topography, etc. Some of major environmental impacts of mining and processing operations are as under

1. Degradation of land.
2. Pollution of surfaces and ground water resources.
3. Effect on growth of vegetation due to leaching out effect of minerals.
4. Surface water pollution and groundwater contamination lead to occupational health hazards etc.
5. Air pollution due to emission of gases.
6. Deforestation affects flora and fauna.
7. Rehabilitation of affected population.

### **Conservation of Minerals**

Conservation of minerals can be done in number of ways and these are as follows,

- Industries can reduce waste by using more efficient mining and processing methods.
- Some mineral products can be recycled. Aluminum cans are commonly recycled. Although bauxite is plentiful, it can be expensive to refine. Recycling aluminium products does not require the large amounts of electric power needed to refine bauxite.
- Products made from many other minerals, such as nickel, chromium, lead, copper, and zinc, can also be recycled.
- Strict laws should be made and enforced to ensure efficient management of mining resources.

### **Role and Responsibilities of engineer in environmental protection**



- Environmental engineers design the different processes to handle large volumes of pollutants with the principles of optimization, socio- economic effects and rapid treatment to convert any objectionable material to a less objectionable material.
- Natural resources Environmental engineer also keep in mind to protect from the effect of disposal of hazardous waste, toxic chemicals and radioactive waste.
- Environmental engineer has a special role of having good coordination with other technocrats and engineers to make rapid advancement in cleaning up the environment with eco-friendly techniques.
- The basic challenging role of an environmental engineer is to make public aware about the environmental degradation and also to impart training in such a way, so that people participate in the programs of keeping the environment clean.

### **Responsibilities of engineers in environment protection.**

To derive solutions for:

- waste water management
- water and air pollution control
- recycling
- waste disposal
- public health

To design:

- municipal water supply systems
- industrial wastewater treatment systems
- plans to prevent waterborne diseases
- improve sanitation in urban, rural and recreational areas
- Provide system and component design that reduce negative impact on environment

To evaluate

- hazardous-waste management systems
- environmental impact of proposed construction projects
- Conduct research and technical audits on environmental impact of project, analyse data and perform quality control checks
- Monitor progress and provide recommendations reports
- Document and maintain plans, requirement, protocols, permits and standard operating procedures.

To advise on:

- treatment
- containment
- Achieving quality, sales, revenue and profitability goals

To develop:

- regulations to prevent mishaps
- resources management schemes
- Integrate latest technologies into systems
- Collaboration with scientists, planners and experts

To implement:

- environmental engineering law
- Jurisdictions about safety of environment and ecosystems



## **Environment, health and safety**

- Protecting the environment and maintaining health and safety at occupation.
- What organizations must do to make sure that their activities do not cause harm to anyone.
- From a safety standpoint, it involves creating organized efforts and procedures for identifying workplace hazards and reducing accidents and exposure to harmful situations and substances.
- It also includes training of personnel in accident prevention, accident response, emergency preparedness, and use of protective clothing and equipment.
- the development of safe, high quality, and environmentally friendly processes, working practices and systemic activities that prevent or reduce the risk of harm to people in general, operators, or patients.
- Ensures well-being through advanced technology and professional development

## **Fire hazards, prevention and precaution.**

Fire is an exothermic chemical reaction between oxygen and fuel. The effect of fire on people takes the form of skin burns.

HAZARD is a situation that possess a level of threat to life, health, property or environment

Common fire hazards include faulty wiring, flammable materials, and electrical appliances left unattended.

## **Fire Prevention Measures**

- Safe Electrical Practices

Proper electrical practices are essential in preventing electrical fires. With the use of high-quality equipment.

- Safe Storage of Flammable Materials

Storage of flammable materials must be done cautiously. Keep them away from sources of heat or open flames.

- Preparing for Fire Emergencies

- i) Fire Extinguishers

Having the right type of fire extinguisher is vital. Use them effectively and keep them accessible in case of emergencies.

- ii) Smoke Detectors

Smoke detectors are first line of defence. Regularly test and maintain them to ensure they are in working order.

- Creating an Effective Evacuation Plan

Plan escape routes and ensure everyone knows them. Designate a meeting point outside the building for accountability.

- Communication

Effective communication during a fire emergency is crucial.

- **Fire Safety Equipment**

- Fire Blankets

Fire blankets can smother small fires. Have them readily available in the kitchen and other high-risk areas.

- Fire Sprinkler Systems

Fire sprinkler systems can rapidly control and extinguish fires. They are highly effective in commercial settings

- Importance of Fire Drills

Regular fire drills at home and in the workplace help people practice their escape plans. The more you practice, the more prepared you'll be during a real emergency.

- Fire Safety in the Workplace

Employers are responsible for ensuring a safe working environment. Fire safety in the workplace is not only a legal requirement but also a moral obligation.

### **Industrial hazards prevention and protection**

INDUSTRIAL HAZARD may be defined as any condition produced by industries that may cause injury or death to personnel or loss of product or property.

INDUSTRIAL SAFETY refers to the protection of workers from the danger of industrial accidents.



## Air and noise pollution

Air and noise pollution is the type of pollution that may occur due to developmental activities such as construction, transportation, and manufacturing.

Air and noise pollution in the environment occurs due to harmful ingredients and unwanted noise, respectively. Air pollution can be due to harmful gases, solid particles or colloidal particles present in the environment. But noise pollution is the occurred due to unwanted noise in the surrounding.

Air pollutants are of two types

- suspended particulate matter, and
- gaseous pollutants like carbon dioxide (CO<sub>2</sub>), NO<sub>x</sub>, etc.

## Protection from air pollution

### 1. Source Control Technology

- Air quality management sets the tools to control air pollutant emissions.
- Control measurements describe the equipment, processes, or actions used to reduce air pollution.
- The extent of pollution reduction varies among technologies and measures.
- The selection of control technologies depends on environmental, engineering, economic factors, and pollutant type.

### 2. Settling Chambers

- Settling chambers use the force of gravity to remove solid particles.
- The gas stream enters a chamber where the gas velocity is reduced. Large particles drop out of the gas and are recollected in hoppers. Because settling chambers are effective in removing only larger particles, they are used in conjunction with a more efficient control device.

### 3. Cyclones

- The general principle of inertia separation is that the particulate-laden gas is forced to change direction. As gas changes direction, the particles' inertia causes them to continue in the original direction and be separated from the gas stream.
- The walls of the cyclone narrow toward the bottom of the unit, allowing the particles to be collected in a hopper.

- The cleaner air leaves the cyclone through the top of the chamber, flowing upward in a spiral vortex, formed within a downward moving spiral. Cyclones are efficient in removing large particles but are not as efficient with smaller particles. For this reason, they are used with other particulate control devices.

#### 4. Absorption

- Removing one or more selected components from a gas mixture by absorption is probably the most important operation in controlling gaseous pollutant emissions.
- Absorption is when a gaseous pollutant is dissolved in a liquid.
- As the gas stream passes through the liquid, the liquid absorbs the gas in much the same way sugar is absorbed in a glass of water when stirred.
- Absorbers are often referred to as scrubbers, and there are various types of absorption equipment.
- The principal types of gas absorption equipment include spray towers, packed columns, spray chambers, and venturi scrubbers.

In general, absorbers can achieve removal efficiencies greater than 95 percent. One potential problem with absorption is the generation of wastewater, which converts an air pollution problem into a water pollution problem.

#### **Protection from noise pollution**

- Road traffic noise can be reduced by better design and proper maintenance of vehicles.
- Noise abatement measures include creating noise mounds, noise attenuation walls, well-maintained roads and smooth surfacing of roads.
- Air traffic noise can be reduced by appropriate insulation and introducing noise regulations for the take-off and landing of aircraft at the airport.
- Industrial noises can be reduced by soundproofing equipment like generators and areas producing a lot of noise.
- Power tools, loud music, land movers, public functions using loudspeakers, etc., should not be permitted at night. The use of horns, alarms, refrigeration units, etc., is to be restricted. The use of noisy firecrackers that cause air pollution should be restricted.
- A green belt of trees is an efficient noise absorber.

#### Environment Protection Acts

##### OBJECTIVES

- The act to provide for protection and improvement of environment

- Prevention of hazards to human beings, other living creature's plants and property
- For prevention and control of environment pollution
- Laying standards for quality of environment
- Restriction of areas for location of industries
- Safeguards for handling hazardous substances
- Research relating to environmental pollution
  
- Water pollution and control of pollution act, 1947
- The air pollution control act, 1981
- The environment protection act, 1986
- The Indian Forest act, 1972
- The wildlife act(protection) 1972 and 2003
- The public liability insurance act, 1991
- The national environment tribunal act, 1995
- Biological diversity act, 2002

#### OBJECTIVES OF ENVIRONMENTAL ISSUES AND ACTS

1. Conservation and survey of flora, fauna (forests and wildlife)
2. Prevention and control of pollution
3. Afforestation and regeneration of degraded areas
4. Protection of environment
5. Ensuring the welfare of animals

#### THE ENVIRONMENT(PROTECTION)ACT, 1986

- ❑ Central govt. to take measures to protect and improve environment
- ❑ Govt. to make rules to regulate environment pollution
- ❑ To regulate the standards of quality of air, water or soil
- ❑ Safeguards for handling of hazardous substances
- ❑ Restriction on location of industries

#### 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.

- The Act lays down restrictions on hunting many animal species.

### **Constitutional Provisions for the Wildlife Act**

- Article 48A of the Constitution of India directs the State to protect and improve the environment and safeguard wildlife and forests. This article was added to the Constitution by the **42nd Amendment** in 1976.
- Article 51A(g) imposes certain fundamental duties for the people of India. One of them is to protect and improve the natural environment including forests, lakes, rivers, and wildlife and to have compassion for living creatures.

### **History of wildlife protection legislation in India**

- The first such law was passed by the British Indian Government in 1887 called the Wild Birds Protection Act, 1887. The law sought to prohibit the possession and sale of specified wild birds that were either killed or captured during a breeding session.
- A second law was enacted in 1912 called the Wild Birds and Animals Protection Act. This was amended in 1935 when the Wild Birds and Animals Protection (Amendment) Act 1935 was passed.
- During the British Raj, wildlife protection was not accorded a priority. It was only in 1960 that the issue of protection of wildlife and the prevention of certain species from becoming extinct came into the fore.

### **Need for the Wildlife Protection Act**

1. A drastic decrease in the flora and fauna can cause ecological imbalance, which affects many aspects of climate and the ecosystem.
2. There were only five national parks in India prior to the enactment of this Act.

### **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.

- It helped India become a party to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (**CITES**).
- The Act prohibited the hunting of endangered species.

- 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.
- The Act created **six schedules** which gave varying degrees of protection to classes of flora and fauna.
- Schedule I and Schedule II (Part II) get absolute protection, and offences under these schedules attract the maximum penalties.
- The schedules also include species that may be hunted.

### **Protected Areas under the Wildlife Protection Act**

There are five types of protected areas as provided under the Act. They are described below.

1. **Sanctuaries:** “Sanctuary is a place of refuge where injured, abandoned, and abused wildlife is allowed to live in peace in their natural environment without any human intervention.”
  1. They are naturally-occurring areas where endangered species are protected from poaching, hunting, and predation.
  2. Here, animals are not bred for commercial exploitation.
  3. The species are protected from any sort of disturbance.
  4. Animals are not allowed to be captured or killed inside the sanctuaries.
  5. A wildlife sanctuary is declared by the State government by a Notification. Boundaries can be altered by a Resolution of the State Legislature.
  6. Human activities such as timber harvesting, collecting minor forest products, and private ownership rights are permitted as long as they do not interfere with the animals' well-being. **Limited human activity is permitted.**
  7. They are open to the general public. But people are not allowed unescorted. There are restrictions as to who can enter and/or reside within the limits of the sanctuary. Only public servants (and his/her family), persons who own immovable property inside, etc. are allowed. People using the highways which pass through sanctuaries are also allowed inside.
  8. Boundaries of sanctuaries are not generally fixed and defined.

9. Biologists and researchers are permitted inside so that they can study the area and its inhabitants.
  10. Sanctuaries can be upgraded to the status of a 'National Park'.
  11. **Examples:** Indian Wild Ass Sanctuary (Rann of Kutch, Gujarat); Vedanthangal Bird Sanctuary in Tamil Nadu (oldest bird sanctuary in India); Dandeli Wildlife Sanctuary (Karnataka).
- 2. National Parks:** "National Parks are the areas that are set by the government to conserve the natural environment."
1. A national park has more restrictions as compared to a wildlife sanctuary.
  2. National parks can be declared by the State government by Notification. No alteration of the boundaries of a national park shall be made except on a resolution passed by the State Legislature.
  3. The main objective of a national park is to protect the natural environment of the area and biodiversity conservation.
  4. The landscape, fauna, and flora are present in their natural state in national parks.
  5. Their boundaries are fixed and defined.
  6. Here, **no human activity is allowed**.
  7. Grazing of livestock and private tenurial rights are not permitted here.
  8. Species mentioned in the Schedules of the Wildlife Act are not allowed to be hunted or captured.
  9. No person shall destroy, remove, or exploit any wildlife from a National Park or destroy or damage the habitat of any wild animal or deprive any wild animal of its habitat within a national park.
  10. They cannot be downgraded to the status of a 'sanctuary'.
11. **Examples:** Bandipur National Park in Karnataka; Hemis National Park in Jammu & Kashmir; Kaziranga National Park in Assam.
- 3. Conservation Reserves:** The State government may declare an area (particularly those adjacent to sanctuaries or parks) as conservation reserves after consulting with local communities.

### **3. Conservation Reserves.**

- 4. Community Reserves:** The State government may declare any private or community land as a community reserve after consultation with the local community or an individual who has volunteered to conserve the wildlife.

**5. Tiger Reserves:** These areas are reserved for the protection and conservation of tigers in India. They are declared on the recommendations of the National Tiger Conservation Authority.

### Schedules of the Wildlife Protection Act

There are six schedules provided in the Wildlife Protection Act.

### Forest Conservation Act 1980

- The Forest Conservation Act 1980 is an important legislation enacted by the Government of India to regulate the diversion of forestland for non-forestry purposes.
- The Act was passed in response to the growing concern over the rapid depletion of India's forests, which had serious environmental and ecological consequences.

### Forest Conservation Act Objectives

- To conserve forests and ensure their sustainable management.
- To regulate the diversion of forestland for non-forestry purposes, such as mining, industrial projects, or infrastructure development.
- To ensure that any diversion of forestland is done only for a specific purpose and with the prior approval of the central government.
- To compensate for any loss of forest cover that may occur due to such diversion by undertaking afforestation and reforestation activities.

### Forest Conservation Act 1980 Salient Features

- Salient features of the Forest Conservation Act 1980 aim to regulate the diversion of forestland for non-forestry purposes.
- ensure the sustainable use of forest resources,
- promote afforestation and reforestation activities.

### Forest Conservation Act 1980 Amendments

- Amendment in 1988-This amendment introduced the concept of “deemed forest” and brought all forestland under the purview of the Act, regardless of its legal classification.

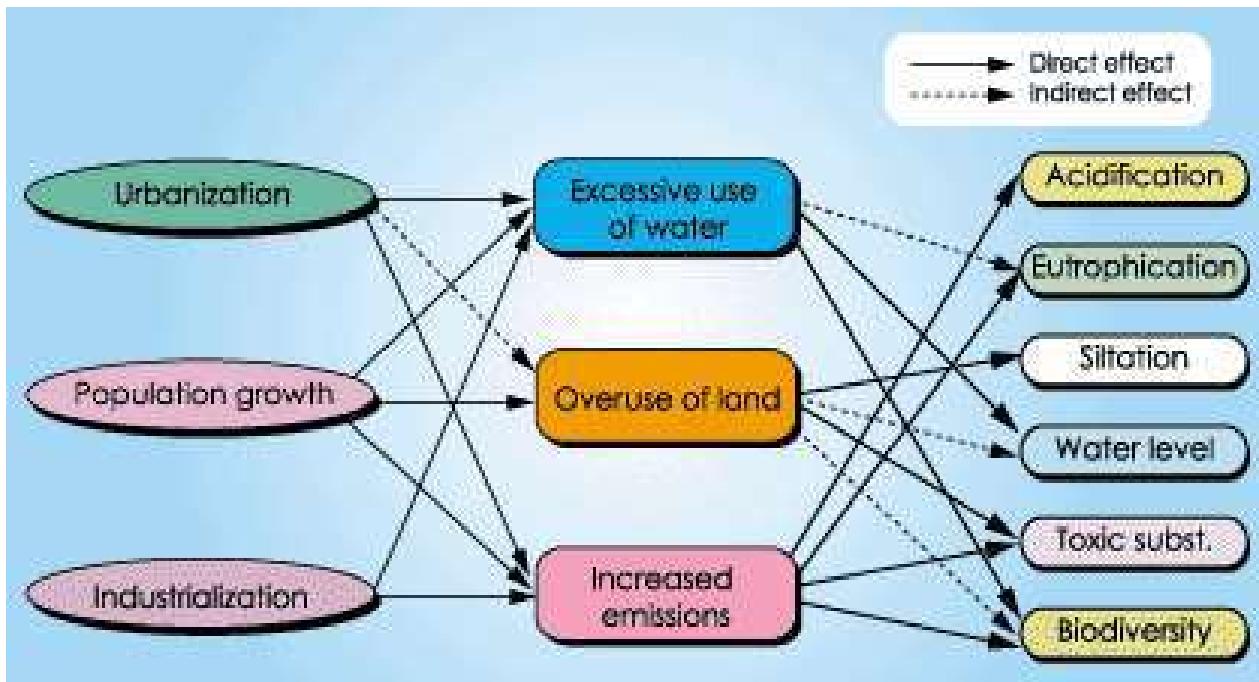
- Amendment in 1991 -This amendment made the central government's approval mandatory for the diversion of forestland for non-forestry purposes, even if it is less than one hectare.
- Amendment in 2003 -This amendment made it mandatory for the user agency to provide an undertaking to carry out compensatory afforestation before the diversion of forestland.
- Amendment in 2015-This amendment introduced the provision for granting forest clearance through a transparent online process, which is now known as the Forest Clearance Portal.
- Amendment in 2017-This amendment allows state governments to carry out compensatory afforestation activities on non-forest land with the approval of the central government

### **Forest Conservation Act 1980 Limitations**

While the Forest Conservation Act 1980 is an important piece of legislation that has helped to protect India's forests and regulate the diversion of forestland for non-forestry purposes, it has certain limitations that have prevented it from achieving its full potential. Some of the limitations are:

- Limited Implementation: Despite the Act's provisions, forest diversion for non-forestry purposes continues to take place, sometimes illegally. The implementation of the Act has been weak in some areas, leading to the degradation and loss of forest cover.
- Lack of Transparency: The decision-making process for forest diversion under the Act lacks transparency, making it difficult for stakeholders to understand the basis for the approvals.
- Limited Scope: The Act focuses primarily on the conservation of forests and the regulation of forestland diversion but does not address issues such as forest management, biodiversity conservation, and sustainable use of forest resources.

### **Population growth aspects and importance and effects on environment.**



- Rapid population growth could lead to environmental deterioration. In many developing countries, continued population growth has resulted in pressure on land, fragmentation of land holding, collapsing of fisheries, shrinking forests, rising temperatures, loss of plant and animal species.
- Severe pressure on forests due to rate of resource use and nature of use. Adverse effects on species diversity.
- Conversion of habitat to some other land use such as agriculture, urban development, forestry operation.
- In India, 70-80 per cent of fresh water marshes and lakes in Gangetic flood plains had been lost in last 50 years.
- Tropical deforestation and destruction of mangroves for commercial needs and fuelwoods is used.
- Poaching and illegal harvesting of wildlife which is a threat to ecosystem and environment.
- Increase in agricultural area, high use of chemical fertilizers, pesticides, and weedicides, water stagnation, soil erosion, soil salinity, and low productivity.
- Degradation of coastal and other aquatic ecosystems for domestic sewage, pesticides, fertilizers, and industrial effluents.
- Environmental degradation is a result of the dynamic interplay of socio-economic, institutional and technological activities.
- Environmental changes may be driven by many factors including economic growth, population growth, urbanization, intensification of agriculture, rising energy use and transportation.

- Environmental pollution is one of the serious problems faced by the people in the country, especially in urban areas, which not only experiences a rapid growth of population due to high fertility, low mortality and increasing rural-urban migration, but also industrialization which is accompanied by growing number of vehicles.
- Population impacts on the environment primarily through the use of natural resources and production of wastes and is associated with environmental stresses like biodiversity, air and water pollution and increased pressure on arable land.
- Increase in the human population activity, pollute the environment and disturb the ecosystem and above all and first one is the pollution. Pollution may be found in air, water and soil, which directly imbalance the ecosystem and environment.

### **Human health and human rights**

- Human rights is defined as the supreme, inherent, and inalienable rights to life, to dignity, and to self-development.
- **Environmental rights** are right to a clean, healthy environment; right to clean air; right to safe drinking water; right to natural food; right to adequate standard of living and adequate housing; right to a safe and healthy workplace; freedom from pollution; preservation of unique site.
- Rights Access is available to all community members, who have the opportunity to use their land in a sustainable manner.
- The community has the right to a sustainable, free of risks lifestyle. Research and monitoring of the land are available so that best practice is enabled and the land is conserved for future generations.
- Deforestation rights It is the citizens' right to ask authorities to supervise all activities in the ecological reservations. Citizens are entitled to take part in political decisions about the environment. It is advisable to preserve the environment, especially if there is the risk of deforestation.
- The government has the right to take measures after any act that can harm the environment.
- **Toxic waste disposal rights responsibilities**

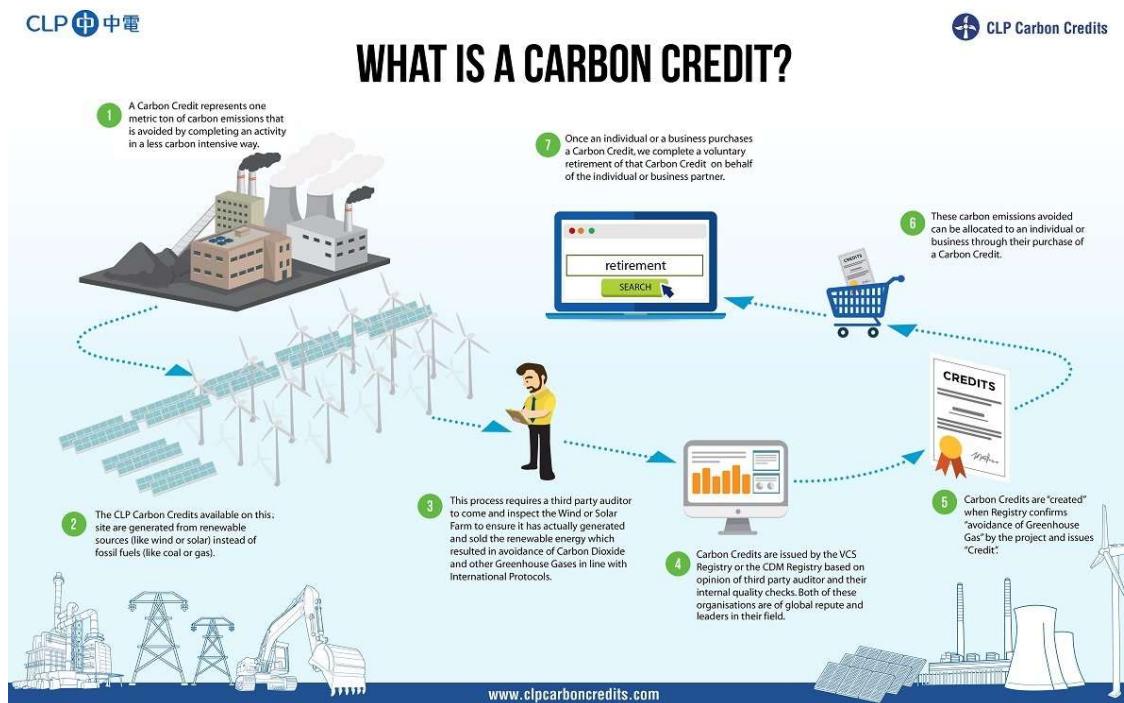
Any citizen is entitled to live in an environmentally safe community. All information held by the governmental, environmental and commercial agencies regarding the disposal of toxic waste and its effects on the environment must be available to all citizens. Citizens can take part in the making of decisions concerning the disposal of toxic waste in their community. The government is

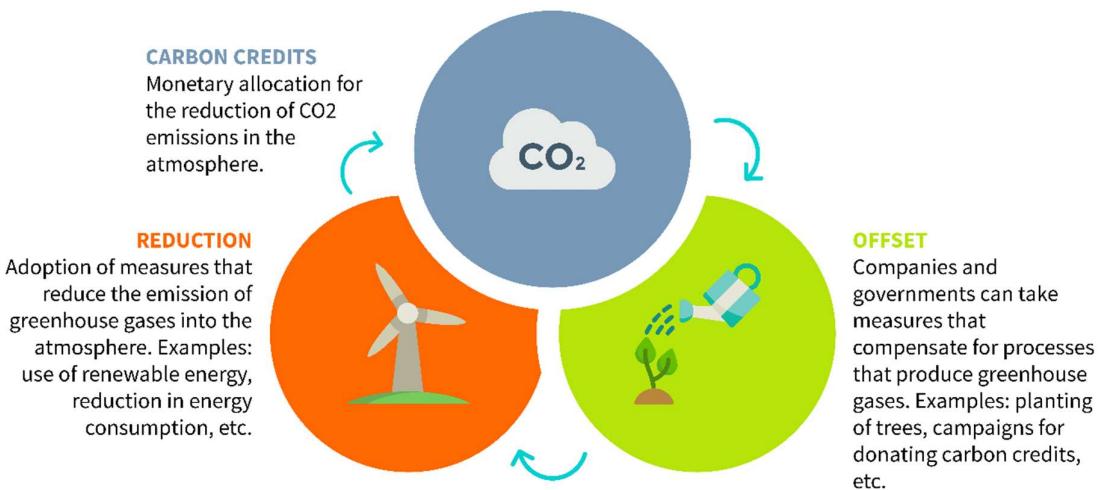
entitled to require and supervise environmentally safe methods to treat toxic waste in industries and communities.

- **Sustainable use of energy and resources**

People have the right to live in clean areas surrounded by water, without harmful chemical substances and radioactivity. Citizens have the right to demand the government to restrict industry and create a cleaner and safer environment and to conserve resources and energy. Citizens can ask the government to be informed about the current condition of pollution including water and air pollution. Government and industry can be required to set up an international cooperation system to solve issues concerning the environment and save resources and energy across the border.

## Concept of Carbon Credits





## **Unit-2 WATER POLLUTION & WASTE WATER TREATMENT METHOD**

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.

### **Water Resource**

#### **1) 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.
- 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.

#### **2) Groundwater Resources:**

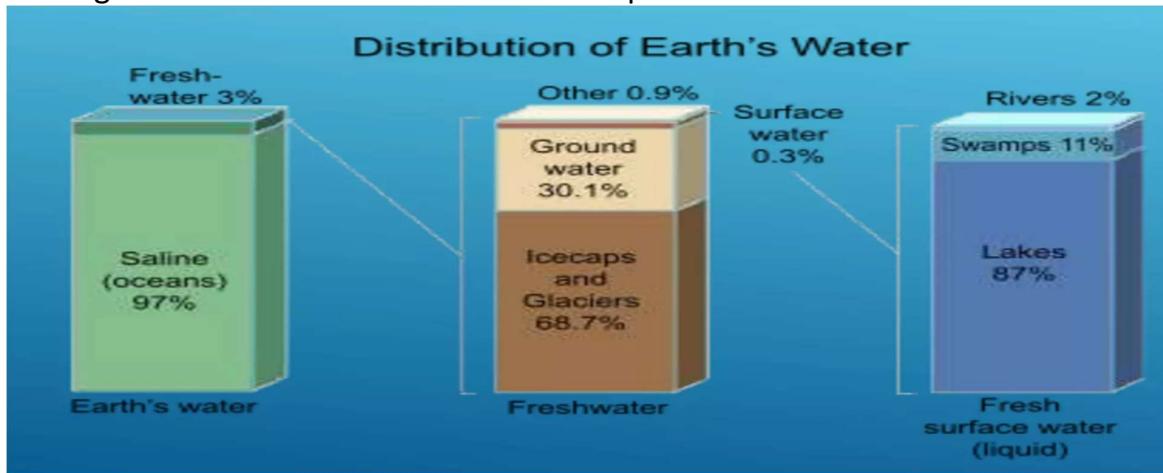
- Of all the freshwater resources, groundwater is the natural resources is perhaps the most abundant. Part of the water that filters down into the soil via layers of dirt, clay, and rock stacks to the uppermost layers, providing water to the plants.
- This water is in the vadose region, which means it is unsaturated. Instead of water, almost all of the pores in the vadose zone are filled with air.
- Humans may use groundwater in an unsustainable manner over an extended period of time without suffering serious repercussions (outcomes)

#### **3) 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.
- 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.
- 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.

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.



## Classification of Water

### BASED ON ITS USAGE

- Domestic Purposes
- Civic or Public Purposes
- Industrial Purposes
- Business or trade purposes

#### 1) DOMESTIC PURPOSES

1-Drinking: Human body contains about 70 percent of water. Consumption of water is required for physiological process such as blood formation, food digestion etc. The quantity of water on an average is about 2 Litres per day for an adult per day. If water for drinking contains undesirable elements it may lead to waterborne diseases like cholera.

2-Cooking: Water required for this purpose will depend upon the stage of advancement of family in particular society in general. The quantity of water an average is about 5 Liters per her per day.

3-Bathing-Water required for bathing purpose will depend on habits of people & type of climate. For an Indian bath 30 to 40 liters per head & for tub bath-50 to 80 liters per head.

4-Washing hands face: Water required for this purpose will depend on habits of people & may roughly be taken as 5 to 10 liters per day

5- Household Sanitary purposes: Water is required for washing clothes, floors utensils, etc. may be assumed to be about 50 to 60 liters per head per day

6- Private Gardening & Irrigation: In case of developed cities there will be particularly no demand of water for this purpose .in underdeveloped cities, the private wells are used to provide water for private gardening & irrigation

7-Domestic Animals & Private vehicles - The amount of water required for use of domestic animals & private vehicles is not much concern to water supply engineer. With growth & development of town, the cattle disappear & commercial stables come into existence. Water required for washing cars & private Vehicles is very low especially in case of poor countries.

## 2) CIVIC OR PUBLIC PURPOSES

1) Road Washing - Roads with heavy amount of dust are to be sprinkled with water to avoid inconvenience to users - Even in case of dust proof roads, periodically. washing is necessary. Water required for this purpose maybe 5 liters per day

2) Sanitation Purposes - Water required in cleaning public sanitary blocks, large markets etc. for carrying liquid wastes from houses. Water required for this purpose will depend on growth of civilization will be about 2 to 3 liters per head per day

3) Fire Demand: Usually a fire occurs in factories & stores. Water required for fire fighting skills should be easily available & always kept stored in the storage reservoir. When a fire occurs, pumps installed on trucks are immediate rushed to the site of fire occurrence & these pumps when connected to fire hydrants are capable of throwing water with high pressure.



### 3) INDUSTRIAL PURPOSES

- Factories: Water required for this process involved in factories will naturally depend on nature of products, size of factory etc. & it has no relation with density of population. Possibility of recycling of water in plant will have appreciable effect on demand of water for project. The quantity of water on average is about 45 Litres per day for an adult per day
- Power stations: They are situated far away from cities & they do not represent serious problem to public water supply
- Railways & Airports: In most of cases, the railways & airports make their own arrangements regarding water requirements. Railways provide 25 to 70 liters of water per head per day. Airport takes 70 liters of water per head per day.



### 4) BUSINESS OR TRADE PURPOSES

- Some Trades such as Dairies, hotels, laundries, motor garages, restaurants, schools, hospitals, cinema halls, theatres etc require large quantity of water.



## ORIGIN, COMPOSITION AND CHARACTERISTICS OF DOMESTIC WASTE WATER

- Wastewater is used water that has been affected by domestic, industrial and commercial use. The composition of all wastewaters is thus constantly changing and highly variable.
- The composition of wastewater is 99.9% water and the remaining 0.1% is solid. This 0.1% contains organic matter, microorganisms and inorganic compounds.
- Domestic wastewater originates from activities such as restroom usage, bathing, food preparation and laundry.
- Commercial wastewater from non-domestic sources, such as beauty salons or auto body repair shops, for example. This wastewater may contain hazardous materials and requires special treatment or disposal.

### Organic content of wastewater

- The organic content of wastewater is made up of human feces, protein, fat, vegetable and sugar material from food preparation, as well as soaps.
- Some of this organic content is dissolved into the water and some exist as separate particles.
- The portion of organic material that does not dissolve but remains suspended in the water is known as suspended solids.
- Wastewater is treated to remove as much organic material as possible

### Implications for microorganisms

Naturally occurring soil and water bacteria eat the organic waste in wastewater and use it as a food and energy source to grow rapidly. In a natural water environment where there is plenty of oxygen dissolved in the water, aerobic bacteria eat the organic material and form a slime of new bacterial cells and dissolved salt-waste products.

If undiluted wastewater is left on its own, anaerobic bacteria decompose the waste organic material and release odorous gases such as hydrogen sulphide. Odor-free gases such as methane and carbon dioxide can also be released.

Where there is an overwhelming amount of wastewater, all the oxygen will be used up and the anaerobic bacteria will take over, making the water go septic. This is ultimately harmful to fish and other forms of life dependent on oxygen, on occasion creating dead zones.

### Inorganic matter

Inorganic minerals, metals and compounds, such as sodium, copper, lead and zinc are common in wastewater from both sewage and wastewater. They can originate from industrial and commercial sources, stormwater, and inflow and infiltration from cracked pipes. Most inorganic substances are stable and cannot be broken down easily by organisms in wastewater.

### Nutrients

Excessive nutrients such as phosphorus and nitrogen can cause eutrophication, which can also be toxic to aquatic organisms. This also promotes excessive plant growth and reduces oxygen availability, altering habitats and potentially endangering certain species.



### Physical characteristics include:

- 1) **Temperature:** The normal temperature of sewage is slightly higher than water temperature. Temperature above normal indicate inclusion of hot industrial wastewaters in sewage
- 2) **Colour:** Fresh sewage is light grey in colour. While the old sewage is dark grey in colour. At a temperature of above 20°C, sewage will change from fresh to old in 2-6 hours.
- 3) **Odour:** Fresh domestic sewage has a slightly soapy or oil odour. Stale sewage has a pronounced odour of Hydrogen Sulphide (H<sub>2</sub>S).

- 4) Solids:** Solids in sewage may be suspended or in solution solids are a measure of the strength of sewage.

Sewage contains both organic and inorganic chemicals. All the test representing these organic and inorganic constituents come under the heading of chemical characteristics. Test like BOD, COD, NITROGEN, PHOSPHOURS, ALKALINITY etc characteristics of sewage.

## **SOLIDS**

- 1) TOTAL SOLIDS : Include both suspended and dissolved solids. It is measured by evaporating a known volume of sample and the weighting the residue. Results are expressed in mg/lit.
- 2) SUSPENDED SOLIDS: These are solids which are retained on a pre-weighed glass fiber filter of 0.45, 103-105°C.
- 3) DISSOLVED SOLID: Filtrate which has passed through 0.45 $\mu$  filter is evaporated in chine dish. The residue gives the dissolved solids.
- 4) SETTLEABLE SOLIDS: It is the fraction of the solids that will settle in an imhoff cone in 30-60 minutes. These are expressed as mg/l.
- 5) Non-volatile solids: They give a rough measure of the organic content or in some instances of the concentration of BIOLOGICAL SOLIDS such as bacteria. The determination is made by ignition of residues on 0.45 $\mu$  filter in a Muffle furnace at 550°C. The residues following the ignition is called non-volatile solids or ash and is rough measure of the mineral content of the waste water. (Note:- Most of the organic and mineral content do volatilize at 550°C and are quite resistant)

Bacteria placed in contact with organic matter will utilize it as food source. In the utilization of the organic material, it will eventually be oxidized to stable end products such as CO<sub>2</sub> and H<sub>2</sub>O.

## **BIOCHEMICAL OXYGEN DEMAND**

The amount of oxygen required by the bacteria to oxidize the organic matter present in sewage to stable end products is known as biochemical oxygen demand.

Significance: -

1. Used in design of waste water treatment plants.
2. Used to measure efficiency of waste water treatment plant.

## **CHEMICAL OXYGEN DEMAND**

It is the amount of oxygen required to oxidize organic matter chemically (biodegradable and non-biodegradable) by using a strong chemical oxidizing agent. ( $K_2Cr_2O_7$ ) in an acidic medium. For a single waste water sample the value of COD will always be greater than BOD.

The oxidant ( $K_2Cr_2O_7$ ) remaining is found out remaining to find  $K_2Cr_2O_7$  considered COD and BOD be interrelated.

Parameter	Range (mg/l)
Total Solids	350 – 1200
Dissolved Solids	250 – 850
Suspended Solids	100 – 350
Settleable Solids	5 – 20 (ml / l)
BOD	100 – 300
COD	250 – 1000
Total Nitrogen	20 – 85
Alkalinity (as $CaCO_3$ )	50 – 200

## ORIGIN, COMPOSITION AND CHARACTERISTICS OF INDUSTRIAL WASTEWATER

- Industrial wastewater originates from industrial or commercial manufacturing processes, such as agriculture, and are usually more difficult to treat than domestic wastes.
- Industrial wastewater's composition varies on an industry-by-industry basis.

## PHYSICAL CHARACTERISTICS

### SOLIDS

Solids removed by settling and separated from wash water are called **sludge**, which may then be pumped to drying beds or filtered for extraction of additional water (dewatering).

The most important characteristic of wastewater  
 Composed of floating matter, settleable matter, colloidal matter and matter in solution.  
 Solids found in wastewater;
 

- **Total solids (TS)**  
Mass **remain** after evaporation at 103-105°C
- **Total Suspended Solid (TSS)**  
Mass remain **on** whatman filter GF/C after drying at 103-105°C
- **Volatile Suspended Solid (VSS)**  
Solids that can be **volatilized and burned off** when TSS are ignited at  $500 \pm 50^\circ C$ . (applied most commonly to wastewater sludge to measure their biological stability)
- **Total dissolved solids (TDS)**  
Those solids that **pass through** the filter and are then evaporated and dried at specified temp.
- **Settleable Solids**  
**Solid settle** at the bottom of an "Inhoff Cone" after 60mins

## TURBIDITY

- Measure of the light -transmitting properties of the water due to presence of suspended material such as clay, organic material, plankton & other particulate material.
- Measured based on comparison of the intensity of light scattered by reference suspension under the same condition.
- Unit = Turbidity Unit (TU)@ Nephelometric Turbidity Unit (NTU)
- Clay @ other suspended particle - not adversely affect health but water containing such particles may require treatment.
- Turbidity excess of 5 TU easily detectable in a glass of water.

## COLOR

- Refer to degree of absorption of light energy in visible spectrum (400-700nm)
- Causes by ;
  - dissolved organic material from decaying vegetation & certain inorganic matter.
  - excessive blooms of algae or growth of aquatic microorganisms.
- But its presence is aesthetically objectionable & needs appropriate treatment.

Activated sludge and trickling filters can remove a certain percentage of some types of colored matter.

Sometimes color matters needs chemical oxidation procedures for removal.

## TASTE & ODOR

- Cause by foreign matter (organic compound, inorganic salts @ dissolved gases).
- Odors are usually caused by gases produced by the decomposition of organic matter or by substances added to the wastewater.
- Industrial wastewater may contain either odorous compounds or compounds that produce odor during the process of wastewater treatment.
- Comes from domestic, agricultural @ natural sources.
- At point of use, drinking water should be free from any objectionable taste @ odor.

## TEMP.

- Very important parameter - its effect on **chemical reactions and reaction rates**, aquatic life, and the **suitability** of the water for beneficial uses.
- The increase in the rate of biochemical reactions that accompanies an increase in temperature, combined with the **decrease in the quantity of oxygen present** in surface waters, can often cause serious depletions in dissolved oxygen concentration in the summer months.
- Abnormally high temperatures can foster the **growth of undesirable water plants and wastewater fungi**
- Most desirable drinking waters are consistently **cool** & do not have fluctuations of more than a few degrees.
- Oxygen is less soluble in warm water** than in cold water
- Industrial establishments that use surface water for **cooling-water purposes** are particularly concerned with the temperature of the intake water.
- Groundwater & surface water** usually meet these criteria.

## pH

- The **hydrogen-ion concentration** is an important quality parameter of wastewater.
- The concentration range suitable for the existence of most biological life is quite narrow and critical.
- Wastewater with an adverse concentration of hydrogen ion is **difficult to treat by biological means**, and if the concentration is not altered before discharge, the **wastewater effluent may alter the concentration in the natural waters**.

# CHEMICAL CHARACTERISTICS

## CHLORIDE

- Most of water contain.
- Amount presence causes by ;
  - Leaching of marine sedimentary deposits
  - Pollution from sea water @ brine @ industrial @ domestic waste.
- Chloride **conc. > 250 mg/L** - noticeable taste
- Domestic water **should contain < 100 mg/L chloride**.

## FLUORIDE

- Some areas - water source contain natural fluoride.
- Excessive fluoride** in drinking water - produce fluorosis (mottling) of teeth.
- Mottled - black spots @ streaks and may become brittle when exposed to large amounts of fluoride.
- Acceptable level for fluoride conc. **between 0.8 - 1.3 mg/L**

S.No	Parameters	Industrial Water
1	Color	Dark yellow
2	pH	8
3	BOD	970 mg/l
4	COD	4500 mg/l
5	Oil and Grease	12
6	Temperature	33°C
7	Electrical Conductivity	600 $\mu\text{S}\text{cm}^{-1}$
8	Suspended Solid	150 mg/l
9	Calcium	361 mg/l
10	Magnesium	268 mg/l
11	Sulphate	419 mg/l
12	Iron	12.8 mg/l
13	Lead	0.065 mg/l
14	Zinc	0.26 mg/l
15	Copper	0.135 mg/l
16	Hardness	300 mg/l

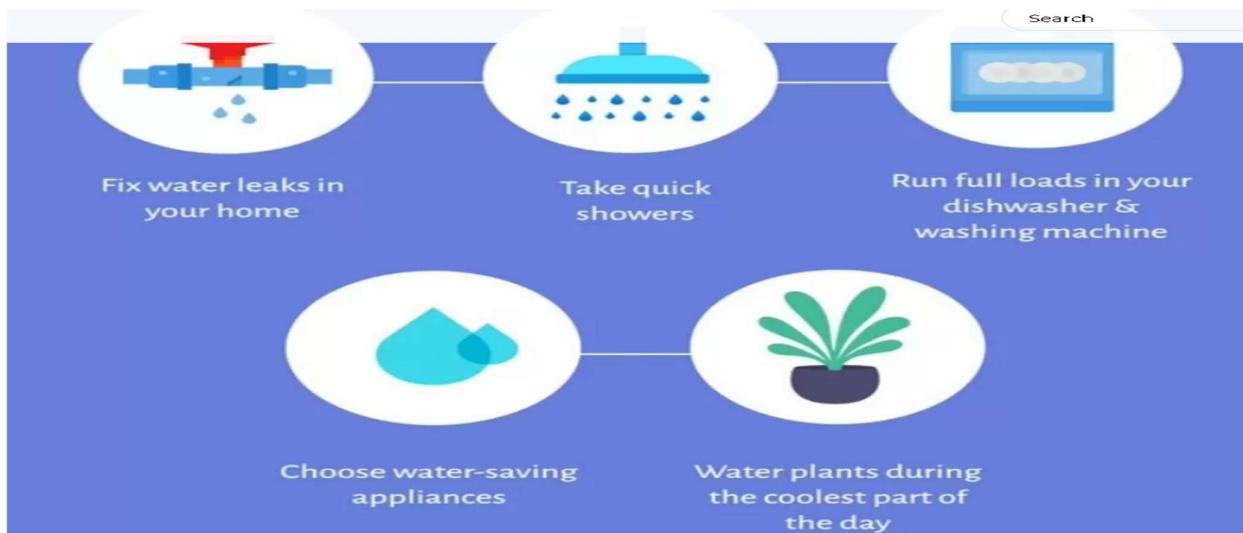
### Standards of Water Parameters

S.No	Characteristics	Desirable limit
<b>I Physico-chemical Characteristics</b>		
i)	pH	6.5 to 8.5
ii)	Total Dissolved Solids (TDS)	500 ppm
iii)	Total Hardness (as $\text{CaCO}_3$ )	300 ppm
iv)	Nitrate	45 ppm
v)	Chloride	250 ppm
vi)	Sulphate	200 ppm
vii)	Fluoride	1 ppm
<b>II Biological Characteristics</b>		
i)	Escherichia Coli (E.Coli)	Not at all
ii)	Coliforms	Not to exceed 10 (In 100 ml water sample)

### WATER CONSERVATION

- Water Conservation is the practice of using water efficiently to reduce unnecessary water usage. Water Conservation includes all the policies, activity and strategies to sustainably manage the natural resources of fresh water, to protect the hydrosphere and to meet the current and future human demand.

- Water Conservation is important to us as 97% of earth's mass is covered with water, yet only 1% is available for our use because the remaining water is salty which cannot be used and other portion is blocked by the glaciers and ice caps.
- Population, household size and growth, all affect the quantity of water used. Factors such as climate change have increased pressure on natural water resources especially in manufacturing and agricultural irrigation.
- The goals of water conservation efforts include ensuring the availability of water for future generations, energy conservation as water pumping, delivery and wasteful treatment facilities consume a significant amount of energy.
- We can conserve water by improving water management practises that reduce the use or enhance the beneficial use of water.
- water conservation method includes rainwater harvesting, considering the rational use of groundwater, by making changes in the cultural model as if the crops are grown by farmers under Agro- climatic conditions, there will be no need for excess water.
- Continue checking leaks at home, turning off the faucet while brushing your teeth, considering waterless car washes etc are also some of the ways for conservation of water.



## **Watershed Management**

A watershed is a body of water that includes rivers, lakes, ponds, streams, and estuaries (tides meet the stream). A watershed is a land area that drains or sheds water at a specific waterbody, like a lake or river. Rainwater or melted snow accumulates and moves silt and other elements downstream in the watershed, depositing them in the receiving waterbody.

A small stream's watershed may be a few hectares, whereas a big river's watershed may be many square kilometres. A watershed should ideally be 1,000 to 2,500 hectares in size for proper planning and execution.

Watershed management is a word used to describe the process of implementing land use and water management strategies to maintain and improve the quality of water and other natural resources within a watershed.

### **Watershed Management Planning:**

Watershed management planning is a method of generating a plan or blueprint for protecting and improving the water quality and other natural resources in a watershed. Watershed boundaries frequently extend beyond political boundaries, extending into neighbouring municipalities and/or states.

### **Objectives of watershed development programs:**

- Development of wastelands, areas which are drought-prone, degraded lands and also desert areas while keeping the local needs and site conditions.
- It also helps in promoting the on-ground economic development and also in improving the life standard, socially and economically, of the poor and disadvantaged people living near the program areas.
- This also reduces the effect of natural climatic problems such as drought and geologic processes on humans and plantations.
- Restoring ecological equilibrium by utilising, conserving, and developing natural resources (e.g., land, water, and vegetative cover).

### **Types of watersheds**

Watershed are classified as per their size and land usage:

Macro watershed (> 50,000 Ha)

Sub-watershed (10,000 to 50,000 Ha)

Milli-watershed (1000 to 10,000 Ha)

Micro watershed (100 to 1000 Ha)

Mini watershed (1-100 Ha)

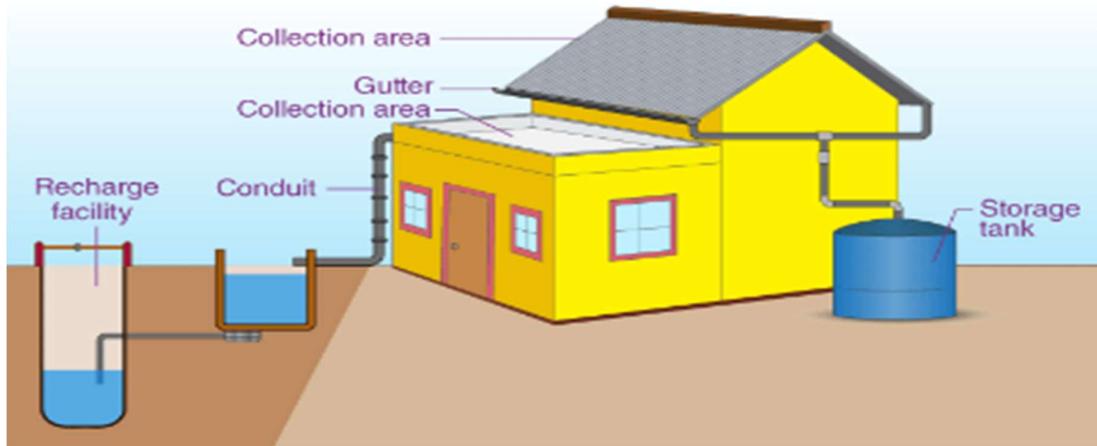
### **Advantage of Watershed Management**

- Watershed management helps regulate pollution of the water and alternative natural resources within the watershed.
- Identifies and Regulates Ecologically Venturous Activities: The activities which happen at a watershed in regular intervals affect the natural resources and water quality.
- Watershed management comprehensively identifies such activities. It makes recommendations to properly address them so that their adverse impacts are often reduced.
- Enhanced Partnership among the stakeholders is rising, which is crucial for the effective management of the land and water resources.
- It is also an economical solution, due to the implementation of watershed management plans when resources are restricted. For example, in places where rainfall is severe, watershed management has proved to double agricultural productivity while aiding the agricultural families through inflated water hardness and diversifying the cropping and farming systems, leading to heterogeneous sources of financial gain.

## Conclusion

The process through which land use and water management strategies are practised to maintain and improve water's quality and other natural resources within a watershed through holistically controlling their use is termed as the watershed management.

Watershed development aims to halt and conserve water where it falls, inside each village, under the leadership of the village watershed committee, so that it can be used for longer periods.



**Rainwater Harvesting**

Rainwater harvesting is the simple process or technology used to conserve rainwater by collecting, storing, conveying and purifying of rainwater that runs off from rooftops, parks, roads, open grounds, etc. for later use.

Broadly there are two ways of harvesting rainwater, namely; surface runoff harvesting and rooftop rainwater harvesting. Rainwater harvesting is the collection and storage of rain for reuse on-site, rather than allowing it to run off. The stored water is used for various purposes, such as gardening, irrigation, etc.

### **1) Surface Runoff Harvesting**

In urban areas, rainwater flows away as surface runoff. This runoff can be caught and used for recharging aquifers by adopting appropriate methods.

### **2) Rooftop Rainwater Harvesting**

It is a system of catching rainwater where it falls. In rooftop harvesting, the roof becomes the catchment, and the rainwater is collected from the roof of the house/building.

It can either be stored in a tank or diverted to an artificial recharge system. This method is less expensive and very useful and, if implemented correctly, helps in augmenting the groundwater level of the area.

**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, stormwater 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.

**Water (Prevention and Control of Pollution) Act, 1974**

The Act came into force in 1974 and is applicable to the states of Assam, Bihar, Madhya Pradesh, Gujrat, Haryana, Tripura, West Bengal, Jammu and Kashmir, Rajasthan, Kerala, and the union territories. It could also be adopted by any state through a resolution passed declaring to adopt the Act. The Water (Prevention and Control) Act, 1974 was introduced to prevent and control water pollution and to restore and maintain the wholesomeness of water for the establishment.

The Act also confers some powers to the established bodies such as the central board and the state board to control pollution of the water bodies.

### **Agencies for controlling Water Pollution**

There are two agencies set up as per the Act for controlling and preventing water pollution.

- Central Board- Central Pollution Control Board
- State Board- State Pollution Control Board.

### **Waste Water**

- Wastewater is used water. It includes substances such as human waste, food scraps, oils, soaps and chemicals.
- In homes, this includes water from sinks, showers, bathtubs, toilets, washing machines and dishwashers.
- Wastewater is defined as any water that has met its intended purpose.
- Wastewater is created by individuals, businesses, agricultural practices like farming, and industrial processes like manufacturing.
- Depending on the source of wastewater, it can be classified into various types.

### **Two Broad Classifications of Wastewater**

Wastewater can be broadly classified into two categories

- 1) Sewage and
- 2) Non-sewage.

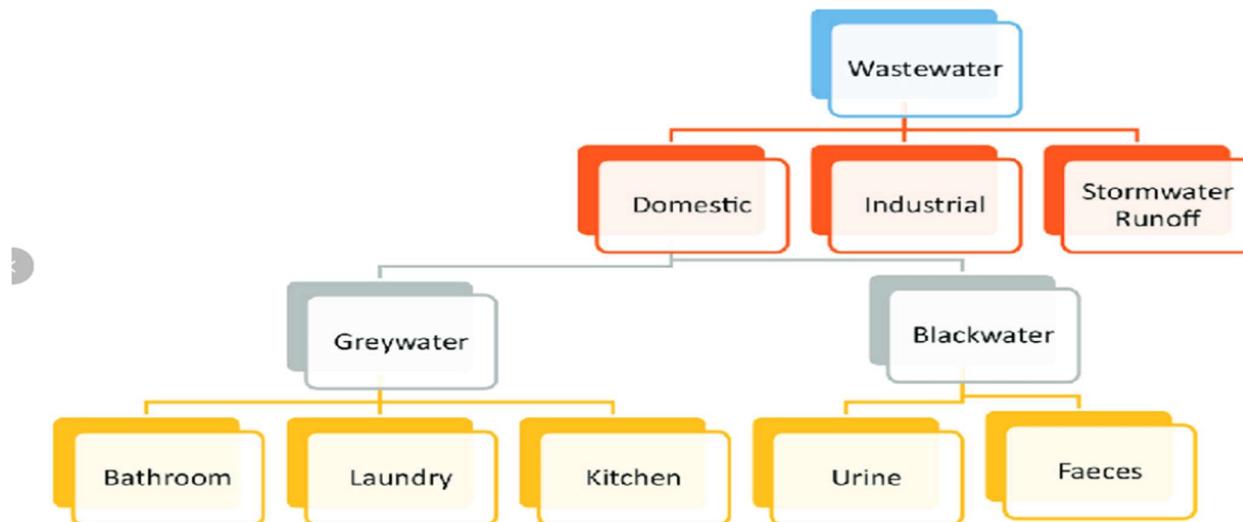
**Sewage** is any wastewater that contains urine and faeces. It is generated via domestic activities. It refers to the toilet and bathroom water from houses, toilets, schools, hotels, restaurants, hospitals, and other places.

**Non-sewage** All other types of waste water are referred to as non-sewage. It includes industrial wastewater, rainwater, storm-water, water from washing vessels, clothes, etc. It doesn't contain human wastes and other harmful pathogens.

### **Wastewater Classification Based on Usage**

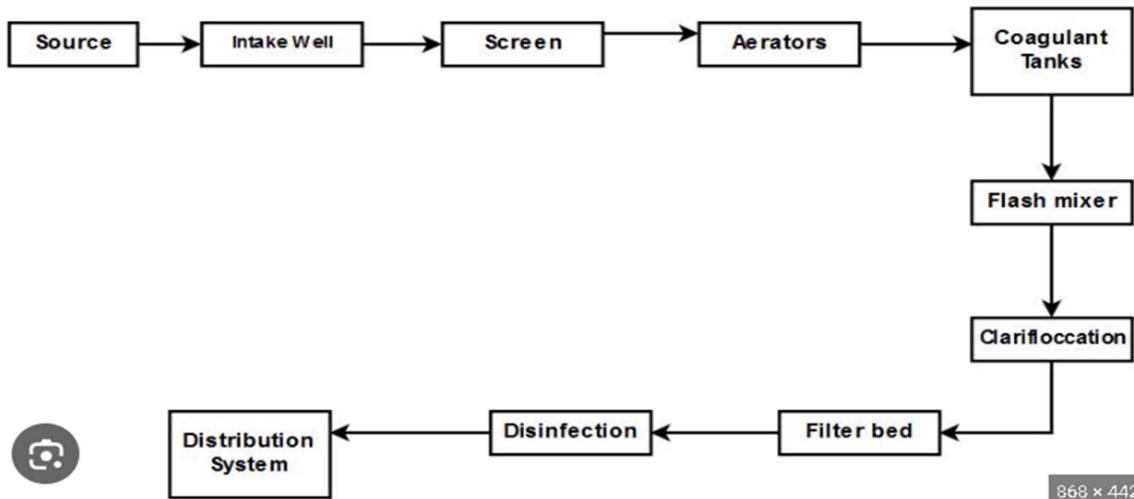
Wastewater can also be further divided into three subcategories based on the source of generation.

- 1) **Blackwater** It refers to wastewater from toilets, bathrooms, dishwashers, kitchen sinks, and washing machines. It contains urine, faeces, toilet paper, discarded food particles, and other household cleaning agents. This water is highly contaminated and is brimming with disease-causing pathogens. Hence, the name Blackwater.
- 2) **Greywater** refers to blackwater minus human contaminants. It's wastewater that doesn't contain urine, faecal matter, and food waste. Generally, water from washing machines and other regular household cleanings (minus bathroom and toilet) water is greywater. Water generated from industrial plants is also greywater. Though greywater contains chemicals and other harmful liquids, it's more suitable for recycling and wastewater treatment. It doesn't have any pathogens, thereby making it more ideal for treatment.
- 3) **Yellow water:** This is generally pure urine. It is urine that is collected from specific sources. It doesn't contain faecal matter, chemicals, food particles, or other contaminants.



Chemical Oxygen Demand (COD) is a test that measures the amount of oxygen required to chemically oxidize the organic material and inorganic nutrients, such as Ammonia or Nitrate, present in water.

### Basic Processes of Water Treatment



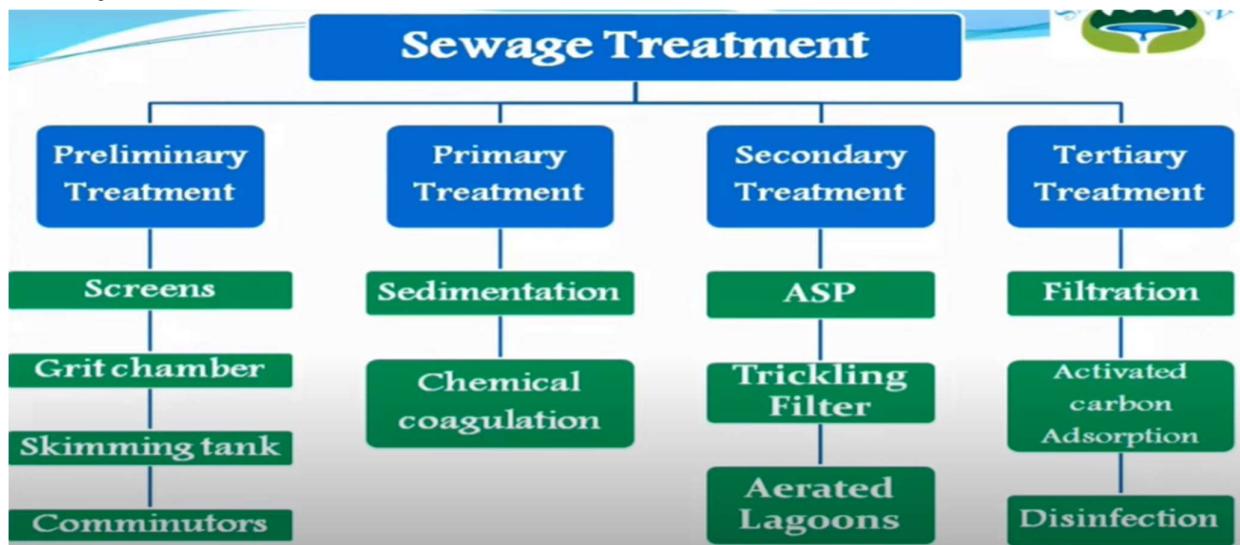
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- **Collection:** Before the water can be treated, it must first be collected from lakes, rivers and reservoirs. Most often, the water is transported from the source to the treatment plant via a complex network of pumps and pipelines, though natural means (such as rivers) may be used.
- **Screening:** The first step in the treatment process is to screen the water to remove larger items of suspended materials, such as rubbish, plants, trees, animals and other debris, these are captured and removed via the use of a large metal screen.
- **Chemical addition:** At this point, chemicals are now added to encourage smaller particles of suspended matter to clump together and form “floc”. The chemicals used to achieve this purpose are called coagulants and there are many different products available.
- **Coagulation:** After the coagulant has been added to the water, it must be mixed at varying speeds over a period of time to allow the flocs to form (this part of the process is known as flocculation).
- **Sedimentation and clarification:** Once the flocs have formed, the water is passed over a sedimentation basin. Here, the clumps of floc particles can settle at the bottom of the basin, where they are removed to a disposal pond.
- **Filtration:** With the larger particles taken out of the water, it must now be filtered through a variety of media such as sand, gravel or granular activated carbon to remove the smaller unwanted particles which still persist.
- **Disinfection:** The remaining water has now had the vast majority of its impurities removed, but it may still contain bacteria, viruses and other microorganisms. In order to kill these elements, it must be treated with enough chlorine to be effective but not too much to affect taste or odour.
- **Storage:** The water is now essentially ready for public consumption, but must be stored until demand for it surfaces. It is most commonly stored in underground or overground

tanks. As well as drinking water, there must also be a stored supply of water for emergencies such as fires.

- **Distribution:** The water is finally sent to homes and businesses around the country via a sophisticated system of pumps, tanks, pipelines, hydrants, valves and meters.

## Theory of Industrial waste Treatment



## Preliminary Treatment

- The purpose of Preliminary Treatment is to remove **floating matter** and **heavy settleable inorganic solids**.
  - It also includes the flow measuring devices.
  - If the floating mater and heavy settleable inorganic solids are not removed then it will affect the primary and secondary mechanical devices.
  - It reduces BOD load of the wastewater by about 5 to 10 %.
  - Units involved:
    - Screens : Floating matters
    - Grit chamber or Detritus tank : Sand and Grit
    - Skimming tank : Oil and grease
    - ~~Comminutors~~ : Grinding and chopping of large solids

## **Primary Treatment**

- The purpose of primary treatment is to remove large suspended solids.
- If preliminary treatment is not given then it removes organic as well as inorganic suspended solids.
- If preliminary treatment is given then it removes organic suspended solids.
- Units involved:
  - Sedimentation
  - Chemical coagulation

## **Secondary Treatment**

- The purpose of secondary treatment is to remove **soluble and colloidal organic matter** which remains after primary treatment.
- Secondary treatment majorly removes biodegradable organic matter by biological action.
- Biological treatment system are designed to maintain a large active mass of bacteria within the system.
- Secondary treatment process classified as:
  - Attached Growth Process; Biological mass is attached to media
  - Suspended Growth Process ; Biological mass in suspension
  - Combined Process

## **Tertiary Treatment**

- The purpose of tertiary treatment is to remove pollutants which are not removed in preliminary, primary and secondary.
- Tertiary treatment removes soluble inorganic compounds such as phosphorous and nitrogen compounds.
- Tertiary treatment aims to reuse the wastewater.

**Tertiary treatment units involved:**

- Filtration
- Activated carbon Adsorption
- Demineralization
- Disinfection

**Air pollution** is defined as excessive foreign matter in the air which adversely affects the well-being of personnel or causes property damage. It also affects plants, animals, the human body, and buildings.

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.

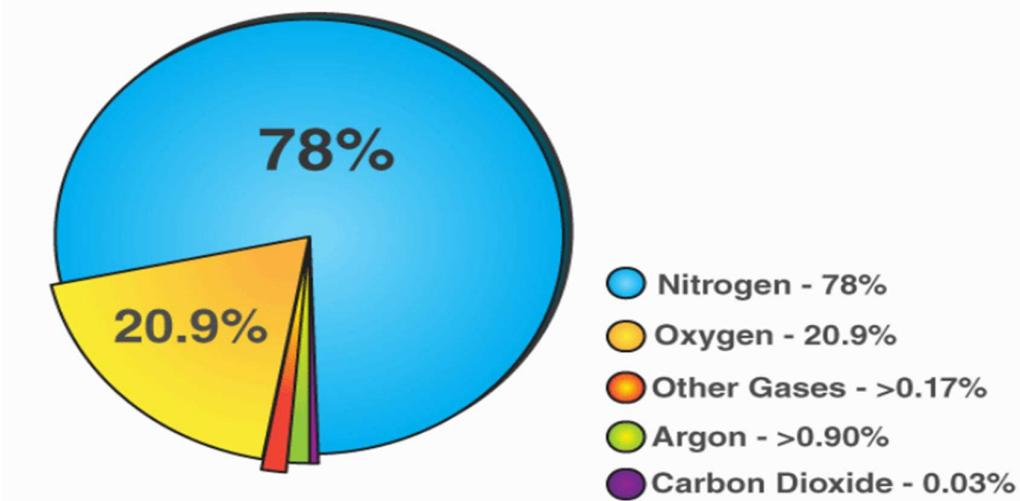
Air Pollution is the release of pollutants such as gases, particles, biological molecules, etc. into the air that is harmful to human health and the environment.

Air pollution is defined as the introduction of pollutants, organic molecules, or other unsafe materials into Earth's atmosphere. This can be in the form of excessive gases like carbon dioxide and other vapours that cannot be effectively removed through natural cycles, such as the carbon cycle or the nitrogen cycle.



#### **Composition of Natural air**

Air is a mixture of gases which makes up the Earth's atmosphere. These gases are colourless and odourless 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 we travel through the layers of the atmosphere. The changes are 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



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 <sub>2</sub>	28.01
Oxygen	20.95	23.20	209445	O <sub>2</sub>	32.00
Argon	0.93	1.28	9339	Ar	39.95
Carbon Dioxide	0.040	0.062	404	CO <sub>2</sub>	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 <sub>2</sub>	2.02
Xenon	8.7 × 10 <sup>-6</sup>	0.00004	0.087	Xe	131.30

## Other Components of Air

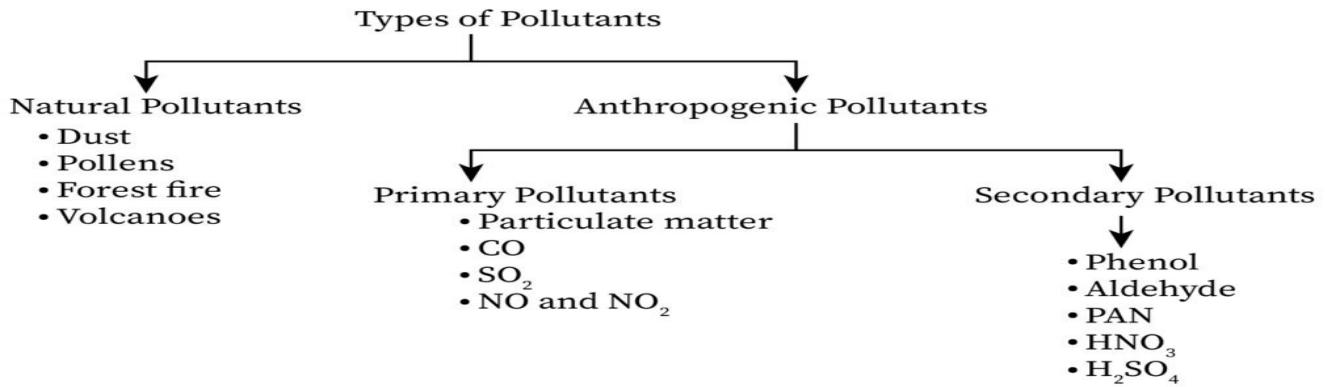
Some other components of air are mentioned below:

- Sulphur dioxide (SO<sub>2</sub>) – 1.0 ppm
- Methane (CH<sub>4</sub>) -2.0 ppm
- Nitrous oxide(N<sub>2</sub>O) – 0.5 ppm
- Ozone(O<sub>3</sub>)-0 to 0.07 ppm
- Nitrogen dioxide (NO<sub>2</sub>) – 0.02 ppm
- Iodine(I<sub>2</sub>)-0.01 ppm
- Carbon monoxide (CO) – 0 to trace ppm
- Ammonia (NH<sub>3</sub>)-0 to trace ppm

## Air pollutants

The pollutants that cause air pollution and degrade air quality can be distinguished into two types based on their origin. They are as follows:

- **Natural:** These types of pollutants occur as a byproduct of natural processes. Such pollutants include dust, pollen grains, forest fire debris, and ash produced from volcanoes.
- **Anthropogenic (human-made):** These types of pollutants originate from human activities. Examples of such pollutants include the emission from automobiles, industries, and power plants.



## Anthropogenic Pollutants

### 1) Primary air pollutants

- Primary air pollutants are the pollutants that are emitted directly from the source to the atmosphere.
- Secondary air pollutants are formed in the lower atmosphere.

Primary air pollutants include oxides of sulphur, carbon, and nitrogen, volatile organic compounds, suspended particulate matter,  $\text{H}_2\text{S}$ , etc.

These pollutants are of concern as they are harmful to humans, animals and plants. They can also be the source of secondary air pollutants.

### Sulphur oxide

About 95% of sulphur oxide is sulphur dioxide  $\text{SO}_2$ . It is a colourless gas with a pungent odour. They are mostly emitted by industries and the burning of fossil fuels. Effects of Sulphur oxide are:

- It interferes with the function of the mucous membrane.
- It creates breathing problems and causes a deficit of oxygen in the body.
- They combine with the rainwater and create acid rain which affects the building's appearance.

### Carbon monoxide

It is mostly due to vehicular exhaust, due to incomplete burning of fossil fuels. It is a colourless, odourless toxic gas. Ill effects on humans are:

- It combines with haemoglobin in the blood and forms complex substances that result even in death.

### Nitrogen oxides

They are generally suspended in the atmosphere by fly ash, tobacco smoke, smog, etc. Effects on human health include:

- It creates eye and nasal irritation.
- It also causes respiratory problems.

### Hydrocarbons

They are compounds of hydrogen and carbon. They undergo photochemical reactions and formaldehyde and ketone which are very harmful.

### **Suspended particulate matter**

They are the mixture of solid particles and liquid droplets which are found in the air. PM2.5 and PM10 are types of particulate matter based on their size.

- PM10 are inhalable coarse particles
- PM2.5 are fine particles.
- Ill effects: respiratory problems, lung cancer

### **Other pollutants**

- Some other primary air pollutants like Lead can cause damage to the liver and kidneys.
- Aromatic hydrocarbons from automobile exhaust are carcinogens that causes cancer.
- Photochemical smog is formed due to the interaction of oxides of nitrogen with sunlight. They give rise to peroxyacetyl nitrate (PAN) and ozone which are very harmful.

## **2) Secondary air pollutant**

- Ozone
- PAN (peroxy acetyl nitrate)
- Photochemical smog
- Aerosols and mists ( $H_2SO_4$ )

### **Ozone ( $O_3$ )**

It is a highly reactive gas composed of three oxygen atom. It is both a natural and a man-made product that occurs in the Earth's upper atmosphere (the stratosphere) and lower atmosphere (the troposphere).

### **PAN**

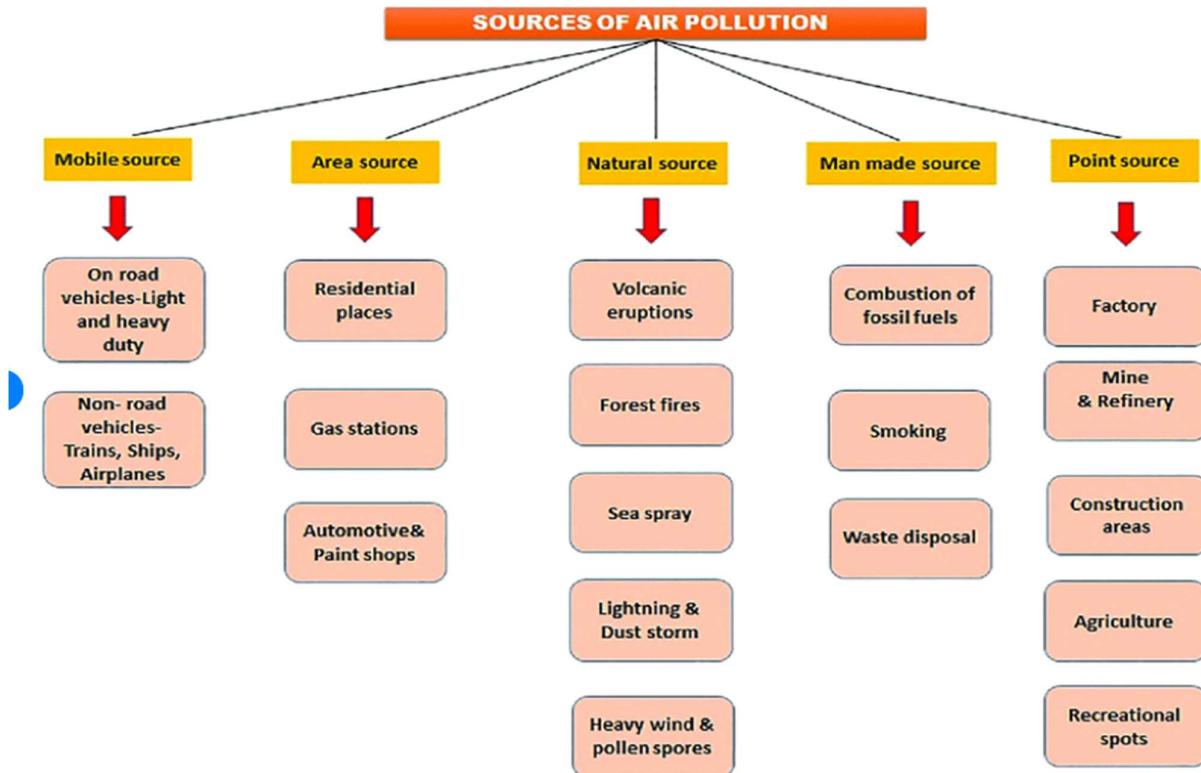
Smog is caused by the interaction of some hydrocarbons and oxidants under the influence of sunlight giving rise to dangerous peroxy acetyl nitrate (PAN).

### **Photochemical smog**

Photochemical smog is a mixture of pollutants which includes particulates, nitrogen oxides, ozone, aldehydes, phenoxyethanol nitrate (PAN), unreacted hydrocarbons, etc. The smog often has a brown haze due to the presence of nitrogen dioxide. It causes painful eyes.

### **Aerosols and mists ( $H_2SO_4$ )**

Aerosols and mists are very fine liquid droplets that cannot be effectively removed using traditional packed scrubbers. These droplets can be formed from gas phase hydrolysis of halogenated acids ( $HCl$ ,  $HF$ ,  $HBr$ ), metal halides, organohalides, sulfur trioxide ( $SO_3$ ), and phosphorous pentoxide ( $P_2O_5$ ).



### Classification of air pollutants

The air pollutants can be classified in many ways as shown below: -

1. According to origin
2. According to state of matter
3. According to sources

#### 1. According to origin

##### A) Primary pollutants

The pollutants that are emitted directly from identifiable sources produced by natural events ( e.g.: dust storms and volcanic eruptions) and human activities (e.g.: emissions from vehicles, industries etc.) are called primary pollutants. E.g.: smoke, dust, oxides of sulphur & nitrogen, hydrocarbons and particulate matter etc.

##### B) Secondary pollutants

The pollutants that are formed in the atmosphere by chemical interactions between primary pollutants and atmospheric constituents are known as secondary pollutants. E.g. Sulphur trioxide, ozone, ketones, sulphuric acid, nitric acid, carbonic acid etc.

#### 2. According to state of matter

##### A) Gaseous air pollutants

These pollutants exist in a gaseous state at normal temperature and pressure. They are carbon dioxide, nitrogen dioxide, sulphur oxides etc.

## **B) Particulate air pollutants**

These are not gaseous substances. They are suspended droplets, solid particles or mixtures of the two.

### **3. According to sources**

#### **A) Natural sources:**

These include volcanic eruptions, deflation of sand and dust, forest or wild fires of natural vegetation, sulphur springs, natural geysers, organic and inorganic decays, vegetative decays, marsh gases, cosmic dust, pollen grains of flowers, photochemical reactions, soil debris etc.

#### **B) Man-made sources**

These include human activities such as industries, factories, urban centres, aircraft, nuclear experiments, automobiles, agriculture, domestic burning of wood and burning of fossil fuels, deforestation, mining, waste treatment plants and power plants.

**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.

#### **Aerosol**

- An aerosol is a suspension of fine solid particles or liquid droplets, in air or another gas. Aerosols can be natural or artificial.

#### **Aerosols can be natural or anthropogenic.**

- Examples of natural aerosols are fog, dust, forest exudates and geyser steam.
- Examples of anthropogenic aerosols are haze, particulate air pollutant and smoke.

#### **Aerosols can be**

- Primary aerosols
- Secondary aerosols

#### **Primary Aerosols**

- These are aerosols that make it into our atmosphere directly from some sort of natural sources.
- For example, smoke and soot from wildfires, desert dust, and ocean waves whipping sea salt into the atmosphere.

#### **Secondary Aerosols**

- These are aerosols that arise when gaseous substances are converted to particulate matter in the atmosphere.
- A great example of this is the sulphur dioxide gas emitted by a volcanic eruption.

#### **Size**

Aerosols particles can be as small as  $0.001\mu\text{m}$  and large as  $100\text{-}200\mu\text{m}$

#### **Sources**

Aerosols have both

- Natural sources.
- Anthropogenic sources

### **Natural sources**

- Ocean
- Volcanic eruptions
- Dust storms
- Forest fires
- Sea spray etc

### **Anthropogenic sources**

- Burning of fossil fuels
- Biomass burning
- Nitrate fertilizers
- Mineral dust from industrial activities etc

### **Chemical composition**

- Typical chemical composition of aerosol can vary at different locations, times and particle size fractions etc
  - The atmospheric aerosol has a very complex and variable chemical composition.
- \* They are generally composed of variable amounts of sulphate, nitrate, ammonium, sea salt and other organic compounds.

### **Sulphate composition**

- The main precursor of sulphate components in troposphere is SO<sub>2</sub>, emitted from anthropogenic sources and volcanoes and dimethyl sulphide (DMs) from biogenic sources especially from marine planktons.
- In stratosphere sulphate aerosols mostly converted from carbonyl sulphide (COS)

### **Nitrate and chloride**

- Nitrate is formed mainly from oxidation of atmospheric nitrogen dioxide (NO<sub>2</sub>).
- Ammonium salts are also common component of atmospheric aerosols.
- Main sources of chloride are sea spray but ammonium chloride particles form during reaction between ammonia and HCl

### **Carbon**

- Carbonaceous materials constitute a large but highly variable fraction of atmospheric aerosols.
- It consists of both elemental carbon (EC) or black carbon (BC) and organic carbon (OC).

### **Effects\Impacts of aerosols**

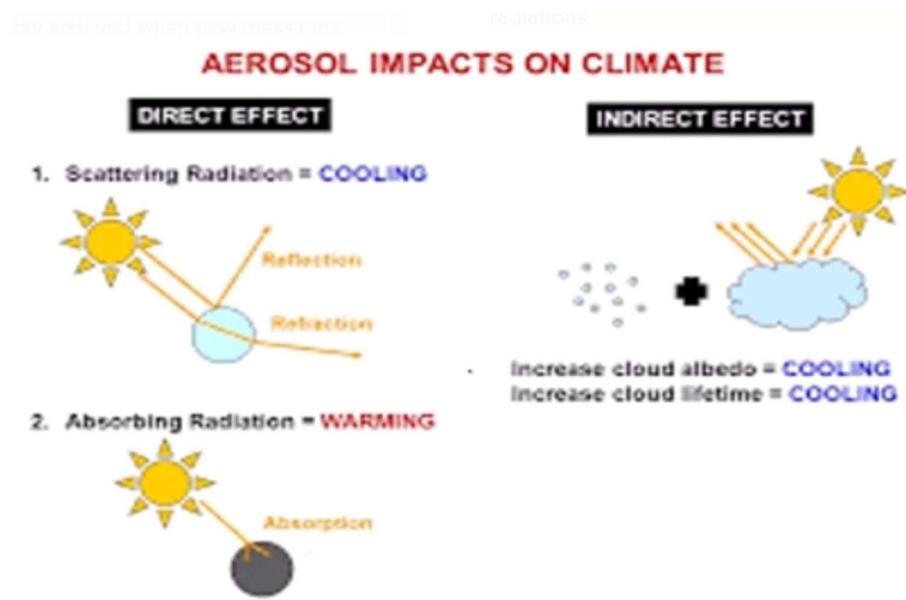
- Direct effect
- Indirect effect
- Other effects

### **Direct effect**

- Aerosols scatter and absorb incoming solar radiations.
- This will mainly lead to a cooling of the surface (solar radiation is scattered back to space)
- It may also contribute to a warming of surface (caused by absorption of incoming solar energy)

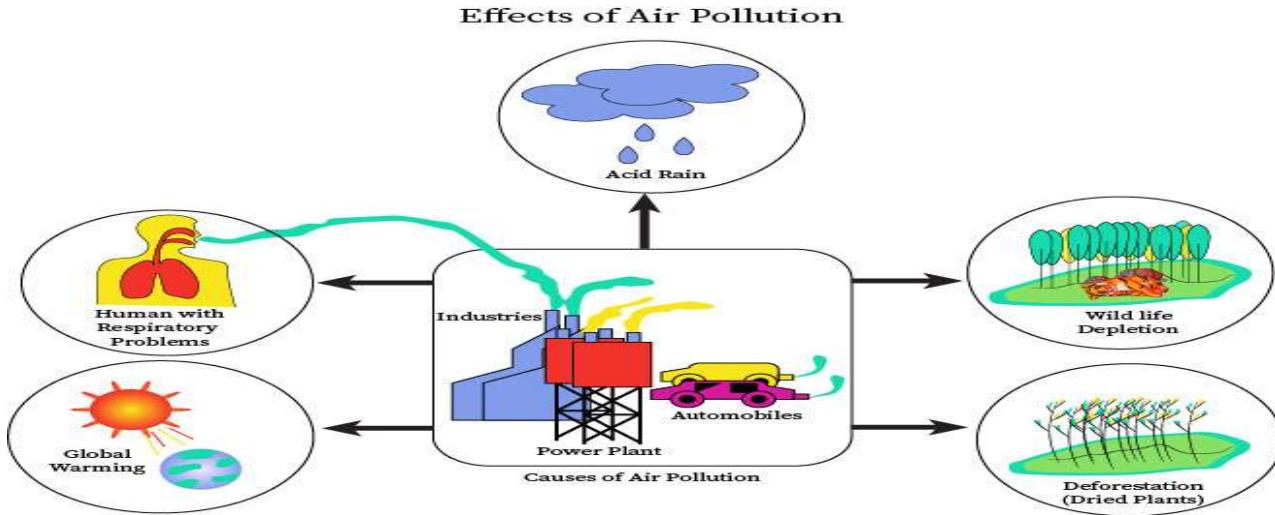
### Indirect effects

- Aerosols influence the formation of clouds.
- They increase the amount of cloud droplets and made clouds more reflective.
- They can increase the lifespans of large storm clouds by delaying rainfall, making the clouds grow larger and live longer, and producing more extreme storms



### Other effects

- When aerosols absorb pollutants, it facilitates the deposition of pollutants to the surface of earth as well as to bodies of water
- This has potential to damage both environment and human health.
- Aerosol particles with an effective diameter smaller than  $10\mu\text{m}$  can enter the bronchi.
- While with an effective diameter smaller than  $2.5\mu\text{m}$  can enter as far as the gas exchange region in the lungs, which can be hazardous to human health



## EFFECT OF AIR POLLUTION

- Clean air is essential for good health.
- Respiratory problems like asthma, bronchitis.
- Chances of pneumonia in children.

There are many organs and bodily functions that can be harmed, the consequences including:

1. Respiratory diseases
2. Cardiovascular damage
3. Fatigue, headaches and anxiety.
4. Irritation of the eyes, nose and throat
5. Harm to the liver, spleen and blood
6. Nervous system damage.

## EFFECT OF SOME AIR POLLUTANT ON HUMAN HEALTH

- 1) Carbon monoxide present in polluted air enters the blood and combines with haemoglobin leading to slow down the circulation of blood. Cause collapse, coma and even death. It also causes headaches, drowsiness, dizziness.
- 2) CO binds to haemoglobin 210 times more tightly than Oxygen.
- 3) Cigarette smoking is responsible for release of CO which interferes with haemoglobin to form carboxy haemoglobin. It causes nausea & headache.
- 4) Sulphur dioxide irritates respiratory tissues and corrosion of tissues of lungs.
- 5) Nitrogen oxides irritates lungs and causes chronic bronchitis and asthma.
- 6) Cadmium damage kidney (Itai-itai - high pain in joint and spine).
- 7) Mercury effect nervous system, eye vision problem, hearing problem (Minamata - neurological syndrome)
- 8) Smog and dust rise allergies. Children have more sensitive lungs; hence they are more easily affected. Cause - Chest pain, nasal and throat problems, eyes irritation and difficulty in breathing.
- 9) Ozone cause coughing and irritation of eye, nose, throat.
- 10) Suspended particles aggravate respiratory tract, leading to bronchitis and asthma. Prolonged exposure can cause cancer.
- 11) Many volatile organic compounds (eg: benzene and formaldehyde) and toxic particulates (eg: lead and cadmium) can cause mutations, reproductive problems or cancer.

## EFFECT OF AIR POLLUTION ON MATERIALS

- 1) The damage due to air pollution on materials is really a serious concern since the service life of buildings is remarkably reduced.
- 2) The effect of air pollution on materials may be seen in terms of discolouration, material loss, structural failing and soiling.
- 3) Both discolouration and structural failure due to air pollution on buildings may be insignificant and that may not involve huge costs. But the effect of corrosion due to acidic deposition costs a lot.
- 4) Air pollutants break down the exterior paint on cars and houses.
- 5) Discoloured monuments, historic buildings, marble statues, other heritage and natural beauty sites.

Main agents of air pollution	Material affected	Kind of damage
SOX – and other acids	Metals	Rusting
SOX, NO <sub>2</sub> acids, and particulates	Textile	Rashes on the body and deformation
SO <sub>2</sub> , H <sub>2</sub> S, O <sub>3</sub> and sticky particulates	Paints	Discolouration and surface damage
HF acidic vapours	Ceramics	Changes in surface structure
Ozone oxidants	Rubber	Cracking and weakening
SOX , and other acidic vapours and sulphur oxides	Building materials, skills and paper	Loss of coat of paint, rust, dustiness, surface damage, and creases

## Effects of air pollution on plants

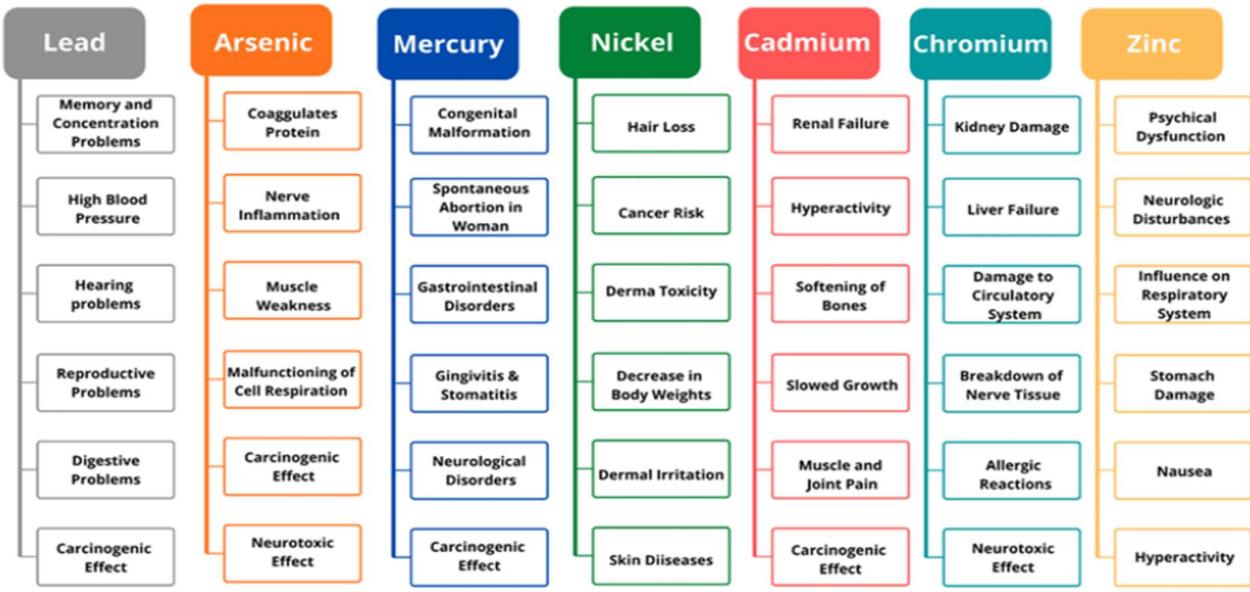
- 1) Chronic exposure of leaves to air pollutants can break down the waxy coating that helps prevent excessive water loss and leads to damage from diseases, pests, drought and frost.
- 2) Such exposure interferes with photosynthesis and plant growth, reduces nutrient uptake and causes the leaves to turn yellow, brown or drop off altogether.
- 3) At higher concentration of sulphur dioxide, most of the flower buds become stiff and hard; eventually fall off from the plants, as they are unable to flower.
- 4) Prolonged exposure to high levels of pollutants from iron smelters, coal- burning power plants and industrial units, as well as from vehicles, can damage trees and other plants.

## Major toxic metals and their effects.

The effects on human health and the environment from exposure to the three most common heavy metal pollutants (mercury, lead and cadmium) include:

- 1) Mercury exposure can harm the brain, heart, kidneys, lungs, and immune system of people of all ages. In babies and young children, the nervous system can be affected making the child less able to think and learn.

- 2) Mercury accumulation in fish may harm the fish and other animals that consume them. Birds and mammals that eat fish are more exposed to mercury than other animals which live in aquatic ecosystems.
- 3) Cadmium is toxic to humans and exposure can cause pulmonary irritation, kidney disease, bone weakness and possibly lung, prostate, and kidney cancer. Food and cigarette smoke are the largest potential sources of cadmium exposure for the general population.
- 4) Lead cause neurodevelopmental effects in children, even at low levels of exposure.
- 5) Cadmium is toxic to humans and exposure can cause pulmonary irritation, kidney disease, bone weakness and possibly lung, prostate, and kidney cancer.



### **The Air (Prevention and Control of Pollution) Act, 1981**

The Air (Prevention and Control of Pollution) Act, of 1981 is an essential legislation enacted by the Indian government to prevent and control air pollution. With rapid industrialization and urbanization, air pollution has become a severe problem in India, causing significant health and environmental impacts.

The Act aims to regulate and monitor air quality, establish pollution control boards, and enforce measures to prevent and control air pollution.

#### **Prime Objectives:**

1. To prevent air pollution by improving the quality and standard of the air.
2. To control air pollution by regulating industries causing air pollution
  - 3. Preventing the emission of pollutants by industries into the atmosphere and abating them as necessary
4. To ensure that the environment and human life is protected from the adverse effects of air pollution
5. Reducing risk to public health from exposure to pollutants in ambient air quality

The Air Prevention and Control of Pollution Act 1981 has many features governed by the Central Pollution Control Board to protect the environment.

1. **Section 3** states that **State Pollution Control Boards and the Central Pollution Control Board** (CPCB) should exercise their range of powers without prejudice.
2. **Section 4** states that if a state has already established a Water Pollution Control Board, then the same should be given joint responsibility and prescribed authority to monitor and control air pollution. The joint body should be called State Pollution Control Board.
3. **Section 5** addresses the concern of a state not having a Water Pollution Control Board. It states that in such a case a new pollution Control Board should be set up.
4. **Section 16** carries the duties of the Central Pollution Control Board.
5. **Section 19**, State Pollution Control Boards can exercise their authority of declaring any area as an Air Pollution Control Area. Consultation with CPCB is required.
6. **Section 22** asserts that no individual or entity is allowed to emit pollutants in the air above the set standards by the relevant Pollution Control Board
7. **Section 26** provides special rights to officers of Boards for Pollution Control to carry out inspections and to take samples of the kinds of air pollutants from chimneys or ducts and test them for the existence of any dangerous pollutant.
8. **Section 28** allows the formation of new State Air Laboratories or declaring any existing lab as a State Air Lab by the relevant SPCBs
9. **Section 37** states that any person or entity who refuses to follow the rules and regulations of Section 21 and Section 22 will be seen as an offense punishable with an **imprisonment of 12 months and 6 months respectively**, but can be stretched to 6 years depending on type and intensity of the offense.

**The key features of the Act include:**

- Advising Central Government of Air and Air Pollution related issues
- Research about the causes and impact of Air Pollution.
- Spread awareness to stop air pollution
- To establish central and State Boards and empower them to monitor air quality and control pollution

**Major environmental phenomenon**

**1) Acid rain**

It is the term used for pollution caused by SO<sub>2</sub> and NO<sub>2</sub> when they combine with atmospheric moisture.

■ When coal, oil and natural gas burn, sulphur dioxide and nitrogen dioxide are produced. These react with water in air and form sulphuric acid and nitric acid and return to the ground in the form of rain, fog or snow.

■ Any precipitate or depositions having a pH lower than 5.6 as a result of contact with airborne particles having an adverse effect on flora & fauna on which it falls is called acid rain.

## **Causes Acid Rain**

Acid rain results when sulphur dioxide (SO<sub>2</sub>) and nitrogen oxides (NO<sub>x</sub>) are emitted into the atmosphere and transported by wind and air currents.

The SO<sub>2</sub> and NO<sub>x</sub> react with water, oxygen and other chemicals to form sulfuric and nitric acids. These then mix with water and other materials before falling to the ground.

While a small portion of the SO<sub>2</sub> and NO<sub>x</sub> that cause acid rain is from natural sources such as volcanoes, most of it comes from the burning of fossil fuels.

The major sources of SO<sub>2</sub>, and NO, in the atmosphere are

- Burning of fossil fuels to generate electricity. Two thirds of SO<sub>2</sub> and one fourth of NO<sub>x</sub> in the atmosphere come from electric power generators.
- Vehicles and heavy equipment
- Winds can blow SO<sub>2</sub> and NO<sub>x</sub> over long distances and across borders making acid rain a problem for everyone and not just those who live close to these sources.
  - (1) Emissions of SO<sub>2</sub> and NO, are released into the air.
  - (2) the pollutants are transformed into acid particles that may be transported long distances.
  - (3) These acid particles then fall to the earth as wet and dry deposition (dust, rain, snow, etc.)
  - (4) May cause harmful effects on soil, forests, streams, and lakes.

## **Measuring Acid Rain**

■ Acidity and alkalinity are measured using a pH scale for which 7.0 is neutral. The lower a substance's pH (less than 7), the more acidic it is; the higher a substance's pH (greater than 7), the more alkaline it is.

■ Normal rain has a pH of about 5.6; it is slightly acidic because carbon dioxide (CO<sub>2</sub>) dissolves into it forming weak carbonic acid. Acid rain usually has a pH between 4.2 and 4.4.

## **Effects of Acid Rain on Fish and Wildlife**

■ The ecological effects of acid rain are most clearly seen in aquatic environments, such as streams, lakes, and marshes where it can be harmful to fish and other wildlife.

■ Some types of plants and animals are able to tolerate acidic waters and moderate amounts of aluminium. Others, however, are acid-sensitive and will be lost as the pH declines.

■ At pH 5, most fish eggs cannot hatch. At lower pH levels, some adult fish die.

## **Effects of Acid Rain on Plants and Trees**

■ Dead or dying trees are a common sight in areas effected by acid rain. Acid rain leaches aluminium from the soil. That aluminium may be harmful to plants as well as animals. Acid rain also removes minerals and nutrients from the soil that trees need to grow.

■ At high elevations, acidic fog and clouds might strip nutrients from trees' foliage, leaving them with brown or dead leaves and needles. The trees are then less able to absorb sunlight, which makes them weak and less able to withstand freezing temperatures.

## Solutions

- There are several solutions to stopping manmade acid rain. Regulating the emissions coming from vehicles and buildings is an important step.
- This can be done by restricting the use of fossil fuels and focusing on more sustainable energy sources such as solar and wind power.
- Also, each person can do their part by reducing their vehicle use. Using public transportation, walking, riding a bike or carpooling is a good start.
- People can also reduce their use of electricity, which is widely created with fossil fuels, or switch to a solar plan.

## 2) Greenhouse effect

The greenhouse effect is a natural process that warms the Earth's surface. When the Sun's energy reaches the Earth's atmosphere, some of it is reflected back to space and the rest is absorbed and re-radiated by greenhouse gases.

Greenhouse gases include water vapour, carbon dioxide, methane, nitrous oxide, ozone and some artificial chemicals such as chlorofluorocarbons (CFCs).

The absorbed energy warms the atmosphere and the surface of the Earth. This process maintains the Earth's temperature at around 33 degrees Celsius warmer than it would otherwise be, allowing life on Earth to exist.

### Causes of greenhouse effect

The main reason for greenhouse effect is the emission of gases like nitrous-oxide, carbon-dioxide, methane, ozone and water vapor. The causes of these emissions have been listed below.

- 1) Deforestation: One of the major reasons for the greenhouse effect is deforestation. With the increase in population, more and more forests are being cut to provide accommodation and other amenities to people. This has led to an increase in the amount of carbon di-oxide in the atmosphere.
- 2) Burning of Fossil Fuels: We all know that burning of fossil fuels, like petroleum and oil, wood and gas results in release of pollutants into the atmosphere. With time, the consumption of fossil fuels, be it for industrial purposes or consumer purposes, has increased and with it, the pollution levels in the world.
- 3) Electrical Appliances: Electrical appliances are amongst the major contributors to the greenhouse effect. Refrigerators, air conditions or some other electric appliances emit gases, known as Chlorofluorocarbons (CFCs).
- 4) Industries: Most of the industries today add to the pollution levels and in turn, lead to the greenhouse effect. Aerosol cans, some foaming agents used in the packaging industry, fire extinguisher chemicals and cleaners used in the electronic industry contribute to this. Even some processes of the cement manufacturing industries can be counted amongst the culprits.

- 5) Automobiles: Automobiles, whether they run on petrol or diesel, create pollution and release harmful gases into the atmosphere. These gases, in turn, create the greenhouse effect in the atmosphere. The forever-increasing use of automobiles has only added to the problem.

### **3) Global Warming**

Global warming is the slow increase in the average temperature of the earth's atmosphere because an increased amount of the energy (heat) striking the earth from the sun is being trapped in the atmosphere and not radiated out into space.

Since the pre-industrial period, human activities are estimated to have increased Earth's global average temperature by about 1 degree Celsius (1.8 degrees Fahrenheit), a number that is currently increasing by 0.2 degrees Celsius (0.36 degrees Fahrenheit) per decade.

#### **Causes global warming**

Global warming occurs when carbon dioxide (CO<sub>2</sub>) and other air pollutants collect in the atmosphere and absorb sunlight and solar radiation that have bounced off the earth's surface.

Normally this radiation would escape into space, but these pollutants, which can last for years to centuries in the atmosphere, trap the heat and cause the planet to get hotter.

These heat-trapping pollutants—specifically carbon dioxide, methane, nitrous oxide, water vapor, and synthetic fluorinated gases—are known as greenhouse gases, and their impact is called the greenhouse effect.

Our current era of global warming is directly attributable to human activity—specifically to our burning of fossil fuels such as coal, oil, gasoline, and natural gas, which results in the greenhouse effect.

The carbon dioxide in the atmosphere has increased by 31% since pre-industrial times, causing more heat to be trapped in the lower atmosphere. Many countries have signed a convention to reduce Green House Gases (GHG) under the United Nations Framework Convention on Climate Change (UNFCCC).

#### **Effects of global warming**

As the heat waves, droughts, and floods associated with climate change become more frequent and more intense, communities suffer and death tolls rise.

If we're unable to reduce our emissions, scientists believe that climate change could lead to the deaths of more than 250,000 people around the globe every year and force 100 million people into poverty by 2030.

Disappearing glaciers, early snowmelt, and severe droughts will cause more dramatic water shortages and continue to increase the risk of wildfires.

Rising sea levels will lead to even more coastal flooding on the Eastern Seaboard.

Forests, farms, and cities will face troublesome new pests, heat waves, heavy downpours, and increased flooding. All of these can damage or destroy agriculture and fisheries.

### **4) Ozone layer depletion**

Ozone layer depletion is the gradual thinning of the earth's ozone layer present in the upper atmosphere.

When chlorine atoms react with ozone molecules, it leads to the depletion of ozone layer and releases oxygen molecules which do not absorb UV radiation.

## **Cause of ozone depletion**

The main cause of ozone depletion and the ozone hole is manufactured chemicals, specially manufactured halocarbon refrigerants, solvents, propellants, and foam-blown agents (chlorofluorocarbons (CFCs), HCFCs, halons).

Since the early 1970's, scientists observed reduction in stratospheric ozone and it was found more prominent in Polar Regions.

## **Effects Of Ozone Layer Depletion**

The depletion of the ozone layer has harmful effects on the human health, animals, environment and marine life.

Studies demonstrate that an increase in UV-B rays causes a higher risk of skin cancer, plays a major role in malignant melanoma development, sunburns, quick ageing, eye cataracts, blindness and weekend immune system.

UV-B rays negatively affect plants, crops. It may lead to minimal plant growth, smaller leaf size, flowering and photosynthesis in plants, lower quality crops for humans. And decline in plant productivity would in turn affect soil erosion and the carbon cycle.

Direct exposure to ultraviolet radiations also leads to skin and eye cancer in animals.

Planktons and zooplankton are greatly affected by the exposure to UV-B rays. These are higher in the aquatic food chain. If the plankton's declines, it would likely have wide-reaching effects for all marine life in the lower food chain.

## **Solutions to Ozone Layer Depletion**

Montreal Protocol was proposed in 1987 to unite the world to cut out production and import of ozone-depleting substances.

One should avoid using pesticides and shift to natural methods to get rid of pests instead of using chemicals.

The vehicles emit a large amount of greenhouse gases that lead to global warming as well as ozone depletion.

## **Air quality standards**

- Air quality standards are generally health-based guidelines which seek to establish the concentrations of air pollutants to which the public can be exposed throughout their lifetime without significant adverse effects at a population level.

- Such standards cannot be totally protective, but risks to all but the most susceptible individuals should be negligible at concentrations below the air quality standard.

### **Types**

The Clean Air Act identifies two types of national ambient air quality standards.

- 1. Primary standards
- 2. Secondary standards

### **Primary standards**

- Apply exclusively to human health

- Primary standards provide public health protection, including protecting the health of "sensitive" populations such as asthmatics, children, and the elderly.

### **Secondary standards**

- The secondary standards are concerned with protecting the environment.
- Apply to property damage and general welfare.
- These are designed to protect public welfare, transportation hazards, damage to animals, crops, vegetation, and buildings.

The six criteria air pollutants (CAP), or criteria pollutants, for which limits are set in the NAAQS (U.S. National Ambient Air Quality Standards) are

- Ozone (O<sub>3</sub>)
- Atmospheric particulate matter.
- Lead
- Sulphur oxides (SO<sub>x</sub>)
- Carbon monoxide (CO)
- Nitrogen oxides (NO<sub>x</sub>).
- These are typically emitted from many sources in industry, mining, transportation, electricity generation and agriculture.
- In many cases they are the products of the combustion of fossil fuels or industrial processes.

Pollutant	Average Time	Concentration ( $\mu\text{g}/\text{m}^3$ or ppm)
PM10	Annual mean	20 $\mu\text{g}/\text{m}^3$
	24 hour mean	50 $\mu\text{g}/\text{m}^3$
PM2.5	Annual mean	10 $\mu\text{g}/\text{m}^3$
	24 hour mean	25 $\mu\text{g}/\text{m}^3$
O <sub>3</sub>	8 hour mean	100 $\mu\text{g}/\text{m}^3$
NO <sub>2</sub>	Annual mean	40 $\mu\text{g}/\text{m}^3$
	1 hour mean	200 $\mu\text{g}/\text{m}^3$
SO <sub>2</sub>	24 hour mean	20 $\mu\text{g}/\text{m}^3$
	10 minutes mean	500 $\mu\text{g}/\text{m}^3$
CO	15	90 ppm
	30	50 ppm
	1 hour	25 ppm
	8 hour	10 ppm
Pb	Annual mean	0.5 $\mu\text{g}/\text{m}^3$

### **AIR (Prevention and Control of Pollution) Act, 1981**

- This is an Act for prevention, control and abatement of air pollution. It is also a comprehensive legislation with more than fifty sections.

It makes provisions for Central and State Boards, power to declare pollution control areas, restrictions on certain industrial units, authority of the Boards to limit emission of air pollutants, power of entry, inspection, taking same samples and analysis, penalties, offences by companies and Government and cognizance of offences etc.

- The Act specifically empowers State Government to designate air pollution areas and to prescribe the type of fuel to be used in these designated areas.
- According to this Act, no person can operate certain types of industries including the asbestos, cement, fertilizer and petroleum industries without consent of the State Board. The Board can predicate its consent upon the fulfilment of certain conditions.

The main objectives of the Act are as follows:

- (a) To provide for the prevention, control and abatement of air pollution.
- (b) To provide for the establishment of central and State Boards with a view to implement the Act.
- (C) To confer on the Boards the powers to implement the provisions of the Act and assign to the Boards functions relating to pollution.

### **METEOROLOGICAL PARAMETERS INFLUENCING AIR POLLUTION**

- Air movements influence the result 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.
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#### **Meteorological data helps:**

- identify the source of pollutants
- predict air pollution events such as temperature inversions and high- pollutant concentration days
- simulate and predict air quality using computer models.
- The meteorological parameters which have the most important influence on the diffusion of pollutants in the atmosphere are
  - 1) wind direction and speed
  - 2) Temperature
  - 3) Humidity
  - 4) Rainfall
  - 5) Solar radiation

## **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.

## **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.

## **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 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.

## **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

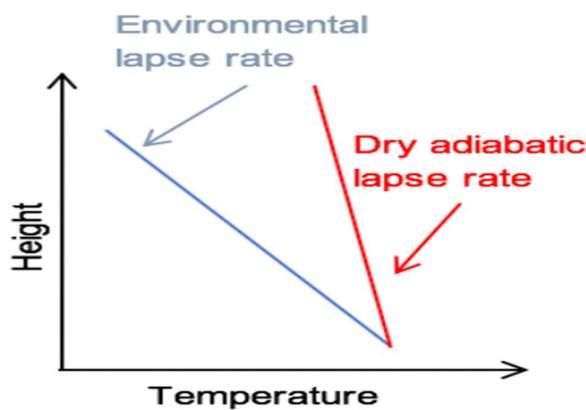
The cloudiness of the sky, time of day and geographic location all affect sunlight intensity.

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

## Environmental lapse rate

The environmental lapse rate (ELR), is the rate of decrease of temperature with altitude in the stationary atmosphere at a given time and location.

As an average, the International Civil Aviation Organization (ICAO) defines an international standard atmosphere (ISA) with a temperature lapse rate of  $6.49 \text{ }^{\circ}\text{C/km}$  ( $3.56 \text{ }^{\circ}\text{F or } 1.98 \text{ }^{\circ}\text{C/1,000 ft}$ ) from sea level to 11 km. From 11 km up to 20 km, the constant temperature is  $-56.5 \text{ }^{\circ}\text{C}$  ( $-69.7 \text{ }^{\circ}\text{F}$ ), which is the lowest assumed temperature in the ISA.

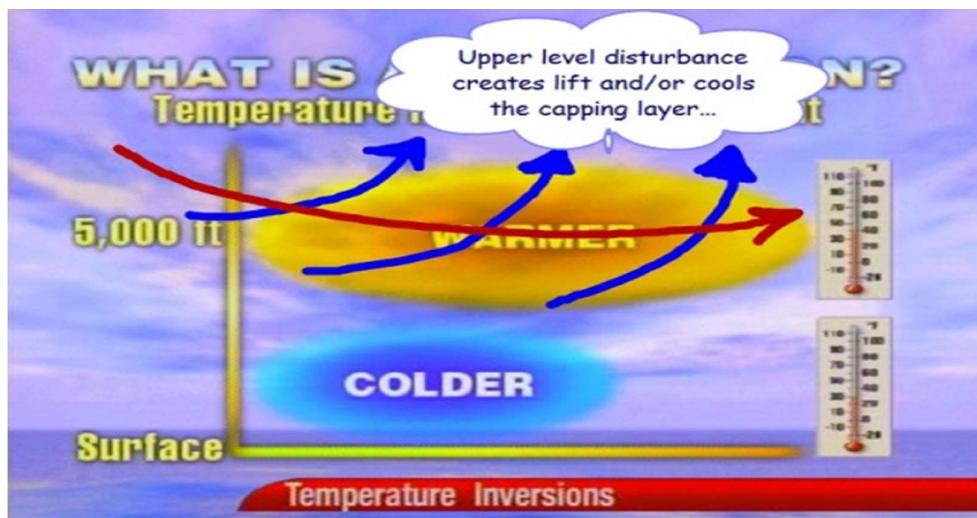


## Temperature inversion

Temperature inversion, also called thermal inversion, a reversal of the normal behaviour of temperature in the troposphere (the region of the atmosphere nearest Earth's surface), in which a layer of cool air at the surface is overlain by a layer of warmer air.

Under normal conditions air temperature usually decreases with height.

Inversions play an important role in determining cloud forms, precipitation, and visibility. An inversion acts as a cap on the upward movement of air from the layers below.



## **ROLE OF NATIONAL GREEN TRIBUNAL IN INDIA**

The National Green Tribunal, established in 2010, as per the National Green Tribunal Act is a specialised judicial body equipped with expertise solely for the purpose of adjudicating environmental cases in the country.

Recognising that most environment cases involve multi-disciplinary issues which are better addressed in a specialised forum, the Tribunal was setup as per recommendations of the Supreme Court, Law Commission and India's international law obligations to develop national laws on environment and implement them effectively.

The Tribunal is tasked with providing effective and expeditious remedy in cases relating to environmental protection, conservation of forests and other natural resources and enforcement of any legal right relating to environment. The Tribunal's orders are binding and it has power to grant relief in the form of compensation and damages to affected persons.

The Tribunal has a presence in five zones- North, Central, East, South and West. The Principal Bench is situated in the North Zone, headquartered in Delhi.

The Central zone bench is situated in Bhopal, East zone in Kolkata, South zone in Chennai and West zone in Pune.

The Tribunal is headed by the Chairperson who sits in the Principal Bench and has at least ten but not more than twenty judicial members and at least ten but not more than twenty expert members.

Any person seeking relief and compensation for environmental damage involving subjects in the legislations mentioned in Schedule I of the National Green Tribunal Act, 2010 may approach the Tribunal.

The statutes in Schedule I are:

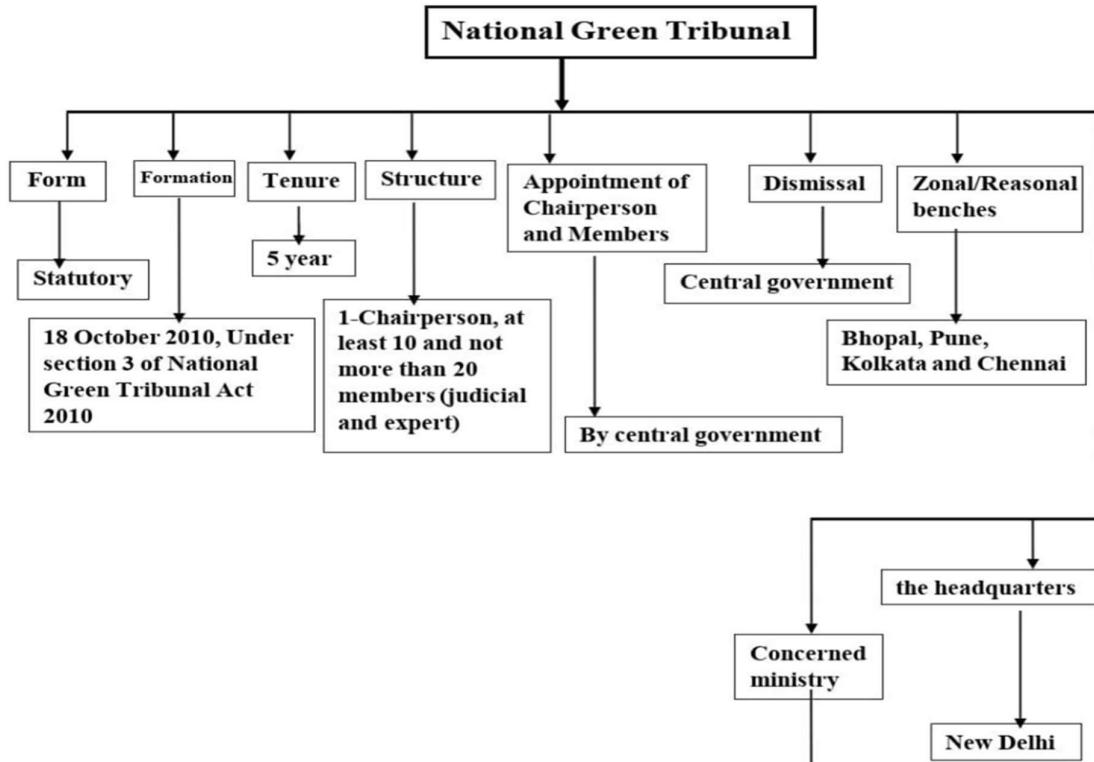
1. The Water (Prevention and Control of Pollution) Act, 1974;
2. The Water (Prevention and Control of Pollution) Cess Act, 1977;
3. The Forest (Conservation) Act, 1980;
4. The Air (Prevention and Control of Pollution) Act, 1981;
5. The Environment (Protection) Act, 1986;
6. The Public Liability Insurance Act, 1991;
7. The Biological Diversity Act, 2002.

The Tribunal has jurisdiction over all civil cases involving a substantial question relating to environment and the question. Additionally, any person aggrieved by an order/direction of any of the Appellate Authorities under the legislations mentioned above can also challenge them before the National Green Tribunal.

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 compensation for any damages caused to persons and properties.
- To handle various environmental disputes that involve multi-disciplinary issues.



## Functions Of The National Green Tribunal

- To resolve the issues related to the environment effectively and quickly.
- To protect and preserve forests.
- Conservation of natural resources.
- To protect the laws related to the environment.
- To provide financial security to any citizen in case of violation of his environment related rights.
- To spread awareness among the general public regarding environmental protection.
- To make efforts to provide clean environment to the common citizens of the country.
- It plays an important role in preventing activities that harm the environment.

## FUNCTION OF REGULATORY BOARDS

### 1) CPCB

- To promote cleanliness of water resources streams and wells in different areas of the States through prevention, control and abate
- To improve the quality of air and to prevent, control or abate air pollution in the country;
- 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 Nation-wide program for the prevention, control or abatement of water and air pollution
- Provide technical assistance and guidance to the State Boards

- Plan and organize training of persons engaged in programs for prevention, control or abatement of water and air pollution
- Organize through mass media, a comprehensive mass awareness program on 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 and 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.
- Lay down and modify, the standards for stream or well, and lay down standards for quality of air (in consultation with the State Government concerned)
- Establish or recognize laboratories to enable the Board to perform such other functions as and when prescribed by the Government of India.
- To issue directions to any industry, local bodies, or other authority for violation of the notified general emission and effluent standards, and rules relating to hazardous waste, bio-medical waste, hazardous chemicals, industrial solid waste, municipal solid waste including plastic waste under the Environment (Protection) Rules, 1986.

2) SPCB

- To plan a comprehensive programme for prevention, control or abatement of pollution of stream and well in the state.
- To advise the State govt. On matters relating to prevention control or abatement of water pollution
- To collect or disseminate information relating to prevention and control or abatement of water pollution
- To encourage, conduct and participate in investigations and research relating to prevention control of pollution.
- To collaborate with CPCB in organizing the training of person engaged in programmes relating to prevention, control or abatement of water pollution.
- To inspect sewage or trade effluent, works and plants for treatment of sewage.
- To lay down, or modify or annul effluent standards for the sewage and trade effluents and for the quality of receiving water and to classify the waters of the state
- To evolve economical and reliable method of treatment of sewage and trade effluent.
- To evolve methods of utilisation of sewage and suitable trade effluents in agriculture.
- To evolve efficient methods of disposal of sewage and trade effluents on land.
- To lay down standard of treatment of sewage and trade effluent to be discharge into in any particular stream.
- To make vary or revoke any order for the prevention and control or abatement of discharge of waste into streams or well.
- To lay down effluent standard to be complied with the person while discharging sewage

## UNIT-4 (ENERGY ENVIRONMENT CLIMATE CHANGE)

### An overview of bureau of energy efficiency (BEE)

- BEE was established on 1st March 2002, under the provisions of the Energy Conservation Act, 2001, under the Ministry of Power.
- The mission of BEE is to assist in developing policies and strategies for energy efficiency with the primary objective of reducing the energy intensity of the Indian economy.
- Functions: It is responsible for regulatory and promotional functions outlined in the Energy Conservation Act, 2001.
- BEE has helped India reduce its energy consumption by around 3.5%.
- The **22<sup>nd</sup> Foundation Day of the Bureau of Energy Efficiency** was recently celebrated with the theme "**Energy Transition through Electrification and Decarbonization in India**" and the **State Energy Efficiency Index 2023** was released.
- The Bureau of Energy Efficiency is an agency of the Government of India, under the Ministry of Power created in March 2002 under the provisions of the nation's 2001 Energy Conservation Act. The agency's function is to develop programs which will increase the conservation and efficient use of energy in India. The government has proposed to make it mandatory for certain appliances in India to have ratings by the BEE starting in January 2010.
- The Bureau of Energy Efficiency is a statutory agency under the Ministry of Power.
- It was created in March 2002 under the provisions of the nation's 2001 Energy Conservation Act.
- BEE's function is to develop programs which will increase the conservation and efficient use of energy.
- It mandatory for certain appliances in India to have BEE ratings.

### Standards & Labelling Program (BEE star label)

- The Objectives of Standards & Labelling Program is to provide the consumer an informed choice about the energy saving.
- The scheme targets display of energy performance labels on high-energy end-use equipment & appliances and lays down minimum energy performance standards.

### The Major Promotional Functions of BEE include:

- Create awareness and disseminate information on energy efficiency and conservation.
- Arrange and organize training of personnel and specialists in the techniques for efficient use of energy and its conservation.
- Strengthen consultancy services in the field of energy conservation.
- Promote research and development.
- Develop testing and certification procedures and promote testing facilities.
- Promote use of energy efficient processes, equipment, devices and systems.
- Take steps to encourage preferential treatment for use of energy efficient equipment or appliances.
- Promote innovative financing of energy efficiency projects.
- Give financial assistance to institutions for promoting efficient use of energy and its conservation.

- On this occasion, BEE expanded the coverage of its star labelling programme by including energy efficient Deep freezer and Light Commercial Air Conditioners (LCAC).
- With this inclusion BEE will cover 26 appliances.
- Deep freezer and Light Commercial Air Conditioners (LCAC) are major energy guzzlers in commercial space.
- The program will be initially launched in voluntary mode from 2nd March, 2020 to 31st December, 2021. Thereafter, it will be made mandatory after reviewing the degree of market transformation in this particular segment of appliances.
- Through this initiative, it is expected to save around 2.8 billion Units by FY2030, which is equivalent to Green House Gas (GHG) reduction of 2.4-million-ton Carbon Dioxide.

### **National Action Plan on Climate Change (NAPCC)**

The National Action Plan on Climate Change (NAPCC) was released by the Prime Minister on 30th June 2008.

It outlines a national strategy that aims to enable the country to adapt to climate change and enhance the ecological sustainability of India's development path. It stresses that maintaining a high growth rate is essential for increasing living standards of the vast majority of people of India and reducing their vulnerability to the impacts of climate change.

There are eight National Missions on climate change:

1. National Solar Mission
2. National Mission for Enhanced Energy Efficiency
3. National Mission on Sustainable Habitat
4. National Water Mission
5. National Mission for Sustaining the Himalayan Eco-system
6. National Mission for a Green India
7. National Mission for Sustainable Agriculture
8. National Mission on Strategic Knowledge for Climate Change

The Principles of NAPCC are:

- Protecting the poor through an inclusive and sustainable development strategy, sensitive to climate change
- Achieving national growth and poverty alleviation objectives while ensuring ecological sustainability
- Efficient and cost-effective strategies for end-use demand-side management
- Extensive and accelerated deployment of appropriate technologies for adaptation and mitigation
- New and innovative market, regulatory, and voluntary mechanisms for sustainable development
- Effective implementation through unique linkages – with civil society, LGUs, and public-private partnerships

### **Challenges faced by NAPCC**

1. The policy was formulated in haste. There was a lot of delay in the approval of ministries.
2. There was a change in government at the centre.
3. The monitoring system was ineffective.
4. Budgetary support was very limited.

## **National Mission for Enhanced Energy Efficiency**

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).

NMEEE aims to strengthen the market for energy efficiency by creating conducive regulatory and policy regime and has envisaged fostering innovative and sustainable business models to the energy efficiency sector. The Mission is implemented since 2011.

NMEEE consist of four initiatives to enhance energy efficiency in energy intensive industries which are as follows:

### **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.

The energy savings achieved by notified industries is converted into tradable instruments called Energy Saving Certificates (ESCert). The ESCerts after issuance by Bureau of Energy Efficiency are traded at Power Exchanges.

PAT is a cyclic scheme where certain notified energy intensive units having threshold energy consumption are given Specific Energy Consumption (SEC) reduction targets over a cycle of three years. PAT Scheme or the Perform, Achieve and Trade Scheme was launched by the Bureau of Energy Efficiency (BEE) in July 2012.

- The chief goal of the scheme is to make India's industrial sector energy efficient.
- The scheme sets energy efficiency targets for industries with those failing to achieve the targets having to pay a penalty. The penalty is based on what remains to be achieved in terms of the target.

## **Market Transformation for Energy Efficiency**

Give more thrust to innovations to produce appliances that are completely affordable and energy-efficient.

Two programmes have been developed i.e. Bachat Lamp Yojana (BLY) and Super-Efficient Equipment Programme (SEEP)

## **Energy Efficiency Financing Platform**

Energy Efficiency Financing Platform (EEFP) was launched as one of the initiatives under National Mission for Enhanced Energy Efficiency to provide a platform to interact with Financial Institutions (FIs) and project developers for implementation of energy efficiency projects.

## **Framework for Energy Efficient Economic Development (FEEED)**

Developing fiscal instruments to leverage financing for Energy Efficiency through risk mitigation:

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.

## **Energy Conservation Building Code**

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:

1. Building Envelope
2. Heating Ventilation and Air Conditioning
3. Lighting
4. Service Water Heating
5. Electric Power and Distribution

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.

#### Purpose

The purpose of this code is to provide minimum requirements for energy efficient design and construction of buildings.

- Building sector -33%
- Commercial sector -8%
- Residential sector-25%
- ECBC compliance building –can save 40 to 60% electricity
- Nation wide mandatory compliance- 1.7 billion KWH
- Its a first step towards Energy conservation
- Developed after extensive research work
- Considered comfort conditions
- Helpful for persons involved in design and construction of ECBC compliant buiding

#### Applicable to buildings

- Minimum energy performance standards for design and construction be prescribed.
- Applies to new construction and major renovation.
- Building components included
  - ❖ Building Envelope (Walls, Roofs, Windows)
  - ❖ Interior and exterior Lighting
  - ❖ HVAC system
  - ❖ Service water heating and pumping
  - ❖ Electrical Systems (Power factor, Transformer)

## Exemptions to buildings

- Buildings that do not use electricity or fossil fuels
- Equipment and portion of the building systems that use energy primarily for manufacturing processes
- When this code is in conflict to safety, health
- Environment codes shall prevail.

## Impact of ECBC – Energy Savings

- Average energy use: For light and HVAC a typical class A office building consumes 200kWh/sq m/Yr.
- Mandatory enforcement of ECBC is likely to reduce the energy use by 30-40% to 120 – 160 200kWh/sq m/Yr.
- Energy saving as per BEE estimate – Saving of 1.7 billion kWh, with national mandatory enforcement, in the first year it self.

### Bio diversity and its conservations

Biodiversity refers to a variety of plant and animal life on Earth. Biodiversity is of three types:

- **Genetic diversity** – It refers to the total number of genes in the genetic makeup of a species. For e.g., the genetic variation shown by Rauwolfia vomitoria (medicinal plant).
- **Species diversity** – It represents the number of species found in an ecological community. For example – The Western ghat has a greater number of amphibian species compared to the Eastern ghats.
- **Ecological diversity** – Greater diversity observed at the ecosystem level in a particular area with its deserts, mangroves, rain forests, etc.

## **Loss of Biodiversity**

- Deterioration in plant production,
- Decreased resistance to environmental issues such as drought, global warming, etc., and
- High variability in certain ecosystem processes such as plant productivity, water use and pest and disease cycles.

## **Causes of Biodiversity Loss**

The following are the causes of the loss of biodiversity.

- Habitat loss and fragmentation
- Over-exploitation
- Co-extinctions

## **Biodiversity Conservation**

Biodiversity conservation is the protection, upliftment and management of biodiversity to derive sustainable benefits for present and future generations.

The enormous value of biodiversity due to their genetic, commercial, medical, aesthetic, ecological and optional importance emphasizes the need to conserve biodiversity. Gradually we are coming to realize that wildlife is not just a game to be hunted, rather it is a gift of nature to be nurtured and enjoyed. A number of measures are now being taken the world over to conserve biodiversity including plants and wildlife. There are two approaches of biodiversity conservation:

- **In situ conservation (within habitat)** – It involves the protection and conservation of a variety of animals and plant species in its natural habitat. It includes biosphere reserves, hot spots, national parks and sanctuaries, wild forests etc.

At present we have 7 major Biosphere reserves, 80 National Parks, 420 wild-life sanctuaries and 120 Botanical gardens in our country covering 4% of the geographic area. The Biosphere Reserves conserve some representative ecosystems as a whole for long-term in situ conservation.

In India we have Nanda Devi (U.P.), Nokrek (Meghalaya), Manas (Assam), Sunderbans (West Bengal), Gulf of Mannar (Tamil Nadu), Nilgiri (Karnataka, Kerala, Tamil Nadu), Great Nicobars and Simlipal (Orrisa) biosphere Reserves. Within the Biosphere reserves we may have one or more National Parks. For example, Nilgiri Biosphere Reserve has two National Parks viz. Bandipur and Nagarhole National Park. A National Park is an area dedicated for the conservation of wildlife along with its environment. It is also meant for enjoyment through tourism but without impairing the environment. Grazing of domestic animals, all private rights

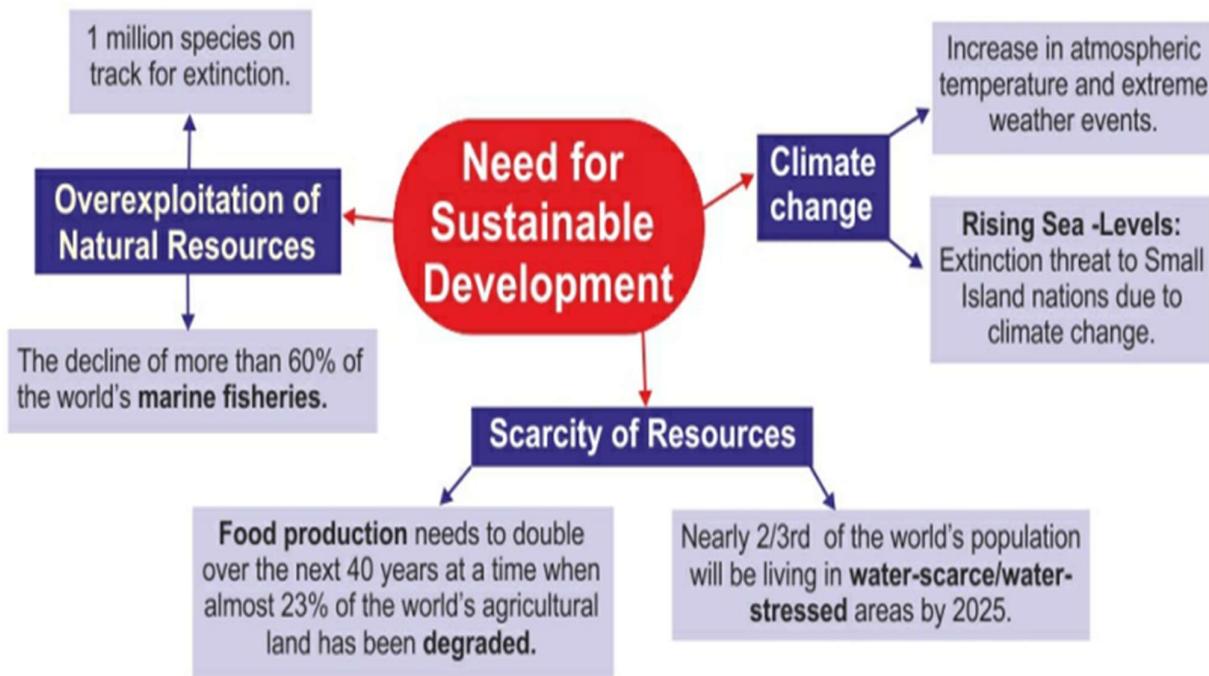
and forestry activities are prohibited within a National Park. Each National Park usually aims at conservation specifically of some particular species of wildlife along with others.

- **Ex-situ conservation** (outside habitats) – It involves the protection and conservation of rare species of animals and plants outside their natural habitats. These include zoos, aquariums, botanical gardens, gene banks, etc.

- National Bureau of Plant Genetic Resources (NBPGR)** is located in New Delhi. Here agricultural and horticultural crops and their wild relatives are preserved by cryo-preservation of seeds, pollen etc. by using liquid nitrogen at a temperature as low as -196°C. Varieties of rice, pearl millet, Brassica, turnip, radish, tomato, onion, carrot, chilli, tobacco, poppy etc. have been preserved successfully in liquid nitrogen for several years without losing seed viability.
- National Bureau of Animal Genetic Resources (NBAGR)** located at Karnal, Haryana. It preserves the semen of domesticated bovine animals.
- National Facility for Plant Tissue Culture Repository (NFPTCR)** for the development of a facility of conservation of varieties of crop plants/trees by tissue culture. This facility has been created within the NBPGR.

### Sustainable development

Development which meets the needs of the present without compromising the ability of future generations to meet their own needs



### Core Elements of Sustainable Development

Three core elements of sustainable development are **economic growth, social inclusion and environmental protection**.

Sustainable **economic growth**, achieving sustainable livelihood, living in harmony with nature and appropriate technology are important for sustainable development.

**Environmental Sustainability:** It prevents nature from being used as an inexhaustible source of resources and ensures its protection and rational use. Aspects such as environmental conservation, investment in renewable energy, saving water, supporting sustainable mobility, and innovation in sustainable construction and architecture, contribute to achieving environmental sustainability on several fronts.

**Social Sustainability:** It can foster gender equality, development of people, communities and cultures to help achieve a reasonable and fairly-distributed quality of life, healthcare and education across the Globe. **Economic Sustainability:** Focuses on equal economic growth that generates wealth for all, without harming the environment. Investment and equal distribution of economic resources. Eradicating poverty in all its forms and dimensions.



### Kyoto Protocol

The Kyoto Protocol was an international treaty which extended the 1992 United Nations Framework Convention on Climate Change (UNFCCC) that commits state parties to reduce greenhouse gas emissions, based on the scientific consensus that global warming is occurring and that human-made CO<sub>2</sub> emissions are driving it.

The Kyoto Protocol was adopted in Kyoto, Japan, on 11 December 1997 and entered into force on 16 February 2005. There were 192 parties (Canada withdrew from the protocol, effective December 2012) to the Protocol in 2020.

The Kyoto Protocol implemented the objective of the UNFCCC to **reduce the onset of global warming by reducing greenhouse gas concentrations** in the atmosphere to "a level that would prevent dangerous anthropogenic interference with the climate system.

The Kyoto Protocol applied to the **seven greenhouse gases**

- 1) Carbon dioxide (CO<sub>2</sub>),
- 2) Methane (CH<sub>4</sub>),
- 3) Nitrous oxide (N<sub>2</sub>O),
- 4) Hydrofluorocarbons (HFCs),
- 5) Perfluorocarbons (PFCs),
- 6) Sulfur hexafluoride (SF<sub>6</sub>),
- 7) Nitrogen trifluoride (NF<sub>3</sub>).
- 8) Nitrogen trifluoride was added for the second compliance period during the Doha Round.

The Protocol was based on the principle of common but differentiated responsibilities: it acknowledged that individual countries have different capabilities in combating climate change, owing to economic development, and therefore placed the obligation to reduce current emissions on developed countries on the basis that they are historically responsible for the current levels of greenhouse gases in the atmosphere.

The Protocol's first commitment period started in 2008 and ended in 2012. All 36 countries that fully participated in the first commitment period complied with the Protocol. However, nine countries had to resort to the flexibility mechanisms by funding emission reductions in other countries because their national emissions were slightly greater than their targets. The financial crisis of 2007–08 reduced emissions. The greatest emission reductions were seen in the former Eastern Bloc countries because the dissolution of the Soviet Union reduced their emissions in the early 1990s. Even though the 36 developed countries reduced their emissions, the global emissions increased by 32% from 1990 to 2010.

A second commitment period was agreed to in 2012 to extend the agreement to 2020, known as the Doha Amendment to the Kyoto Protocol, in which 37 countries had binding targets: Australia, the European Union (and its then 28 member states, now 27), Belarus, Iceland, Kazakhstan, Liechtenstein, Norway, Switzerland, and Ukraine. Belarus, Kazakhstan, and Ukraine stated that they may withdraw from the Kyoto Protocol or not put into legal force the Amendment with second round targets. Japan, New Zealand, and Russia had participated in Kyoto's first-round but did not take on new targets in the second commitment period. Other developed countries without second-round targets were Canada (which withdrew from the Kyoto Protocol in 2012) and the United States (which did not ratify). Canada's decision to withdraw was to the dismay of Environment minister, Peter Kent. If they were to remain as a part of the protocol, Canada would be hit with a \$14 billion fine, which would be devastating to their economy, hence the reluctant decision to exit. As of October 2020, 147 states had accepted the Doha Amendment. It entered into force on 31 December 2020, following its acceptance by the mandated minimum of at least 144 states, although the second commitment period ended on the same day. Of the 37 parties with binding commitments, 34 had ratified.

Negotiations were held in the framework of the yearly UNFCCC Climate Change Conferences on measures to be taken after the second commitment period ended in 2020. This resulted in the 2015 adoption of the Paris Agreement, which is a separate instrument under the UNFCCC rather than an amendment of the Kyoto Protocol.

## **Conference of the parties**

A conference of the parties is the supreme governing body of an international convention (treaty, written agreement between actors in international law). It is composed of representatives of the member states of the convention and accredited observers. Scope of the COP is to review the "implementation of the Convention and any other legal instruments that the COP adopts and take decisions necessary to promote the effective implementation of the Convention".

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.

The first global conference on climate change was held in 1972 in Stockholm, Sweden.

This conference ushered in numerous global negotiations and international agreements on the environment.

All of these culminated in the establishment of the United Nations Framework Convention on Climate Change (UNFCCC) in Rio de Janeiro in Brazil, in 1992.

The treaty sets limits on GHG emissions in countries, but these are not binding and there are no enforcement mechanisms either.

However, there are provisions for updates or protocols that can be used to set legally binding emission limits on countries.

The parties to the convention meet annually in the Conference of the Parties or COP to review the progress under the convention.

The COP has been meeting biennially since 2001, and has held 14 sessions. UNCCD COP15 was held from 9-20 May 2022 in Abidjan.

The 2023 UN Climate Change Conference will convene from 30 November to 12 December 2023 in Dubai, United Arab Emirates (UAE). It will comprise:

- The 28th meeting of the Conference of the Parties (COP 28);
- The fifth meeting of the COP serving as the Meeting of the Parties to the Paris
- The 18th meeting of the COP serving as the Meeting of the Parties to the Kyoto Protocol
- The 59th meeting of the Subsidiary Body for Implementation (SBI 59); and
- The 59th meeting of the Subsidiary Body for Scientific and Technological Advice (SBSTA 59).

## **Clean Development Mechanism**

- The UNFCCC adopted the Kyoto Protocol in December 11, 1997, and enforce in 2005.
- The Kyoto Protocol has three Flexible Market mechanisms include:

- 1) Clean Development Mechanism (CDM)
- 2) Emission Trading
- 3) Joint Implementation (JI)

- Clean Development Mechanism (CDM) is a unique instrument based on understanding and cooperation among the nations for adopting a new economic outlook for activities aiming at protecting the world eco-system.
- 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 (Annex B Party) 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 CO<sub>2</sub>, which can be counted towards meeting Kyoto targets.

## **CDM OBJECTIVE**

- To assist developing countries in achieving sustainable development & in contributing to ultimate objectives of United Nations Framework Convention on Climate Change (UNFCCC)
- To assist developing countries in achieving compliance with their qualified emission limit & reduction commitments.
- Lower Green House Gas emission and stop Ozone layer depletion.

## **GOALS**

- Guide Developing nations to develop sustainable methods
- Assist the developed nations to reduce their emissions
- Help countries to find new methods to reduce emission.

## **Advantages**

- Based emissions reduction activities in the developing country establishes this mechanism.
- Reducing the dependency on fossil fuels
- Reducing the emission involved in manufacturing process.
- Clean Environment.

## **Disadvantages**

- Focuses too much on carbon emissions and doesn't address other pollutants, such as sulfur dioxide and nitrogen oxides, which either do direct harm to human health and/or can be addressed using technology.
- Developing countries emit more than Developed countries.